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VOL. XXXIII.

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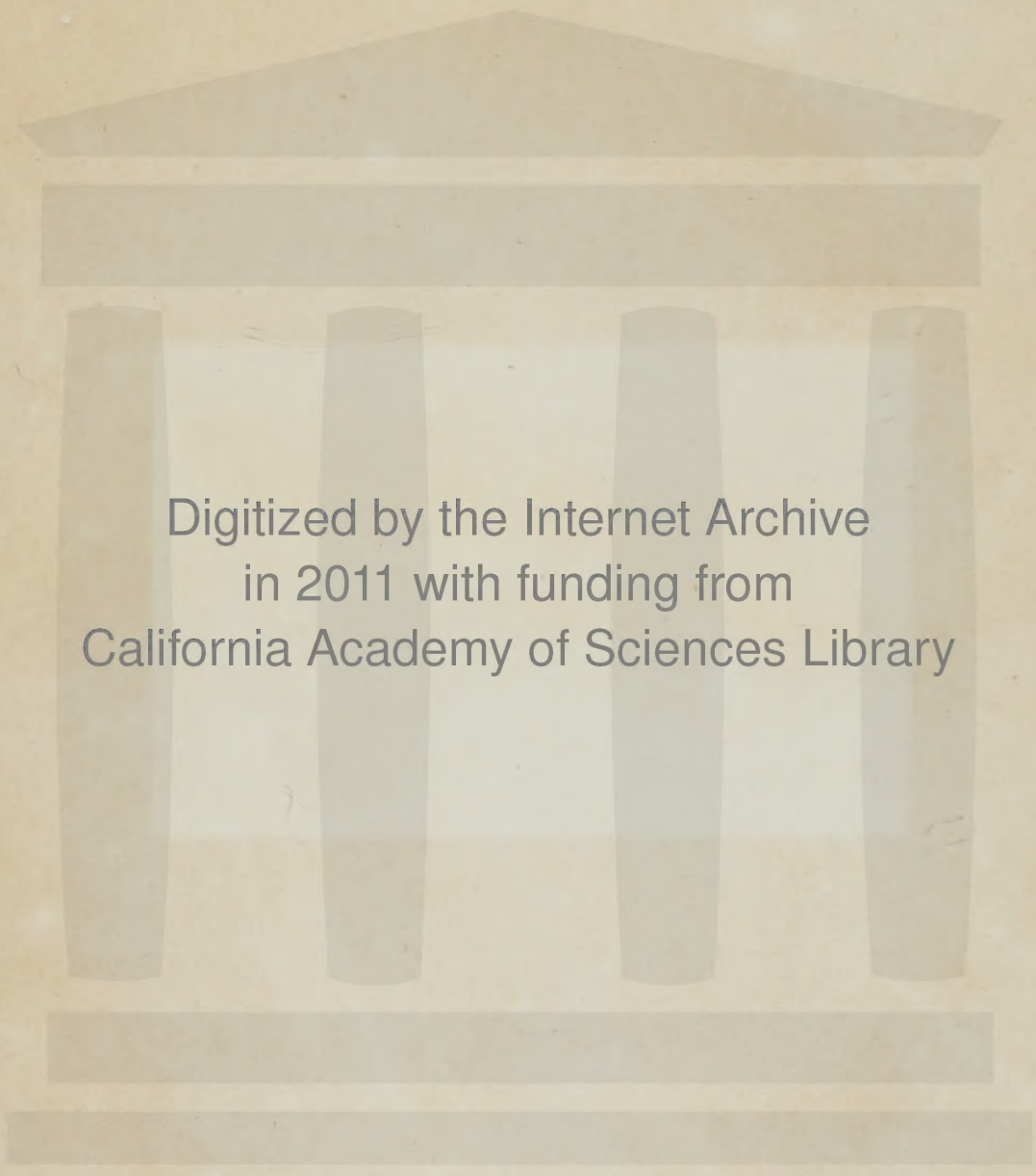
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AND

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II. A CLASSIFIED LIST OF THE MONOGRAPHS COMPLETED, IN COURSE OF PUBLICATION, AND IN PREPARATION, WITH THE NAMES OF THEIR RESPECTIVE AUTHORS;

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V. A STRATIGRAPHICAL LIST OF THE BRITISH FOSSILS FIGURED AND DESCRIBED IN THE YEARLY VOLUMES.

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Showing the ORDER *of publication; the* YEARS *during which the Society has been in operation; and the* CONTENTS *of each yearly Volume.*

Vol. I. Issued for the Year	1847	The Crag Mollusca, Part I, Univalves, by Mr. S. V. Wood, 21 plates.
„ II. „	1848	The Reptilia of the London Clay, Part I, Chelonia, &c., by Profs. Owen and Bell, 38 plates. The Eocene Mollusca, Part I, Cephalopoda, by Mr. F. E. Edwards, 9 plates.
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CATALOGUE OF WORKS—Continued.

Vol. XVIII.	Issued for the Year 1864	The Fossil Echinodermata, Vol. II, Part II (Liassic Ophiuroidea), by Dr. Wright, 6 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part III, by Mr. J. W. Salter, 11 plates. The Belemnitidæ, Part II, Liassic Belemnites, by Prof. Phillips, 7 plates. The Pleistocene Mammalia, Part I, Introduction, Felis spelæa, by Messrs. W. Boyd Dawkins and W. A. Sanford, 5 plates. Title-pages, &c., to the Monographs on the Reptilia of the London Clay, Cretaceous, and Wealden Formations.
„ XIX.*	„ 1865	The Crag Foraminifera, Part I, No. 1, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, 4 plates. Supplement to the Fossil Corals, Part I, Tertiary, by Dr. Duncan, 10 plates. The Fossil Merostomata, Part I, Pterygotus, by Mr. H. Woodward, 9 plates. The Fossil Brachiopoda, Part VII, No. 1, Silurian, by Mr. Davidson, 12 plates.
„ XX.*	„ 1866	Supplement to the Fossil Corals, Part IV, No. 1, Liassic, by Dr. Duncan, 11 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part IV (Silurian), by Mr. J. W. Salter, 6 plates. The Fossil Brachiopoda, Part VII, No. 2, Silurian, by Mr. Davidson, 10 plates. The Belemnitidæ, Part III, Liassic Belemnites, by Prof. Phillips, 13 plates.
„ XXI.*	„ 1867	Flora of Carboniferous Strata, Part I, by Mr. E. W. Binney, 6 plates. Supplement to the Fossil Corals, Part IV, No. 2, Liassic, by Dr. Duncan, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part II, by Dr. Wright, 14 plates. The Fishes of the Old Red Sandstone, Part I, by Messrs. J. Powrie and E. Ray Lankester, 5 plates. The Pleistocene Mammalia, Part II, Felis spelæa, continued, by Messrs. W. Boyd Dawkins and W. A. Sanford, 14 plates.
„ XXII.*	„ 1868	Supplement to the Fossil Corals, Part II, No. 1, Cretaceous, by Dr. Duncan, 9 plates. The Fossil Merostomata, Part II, Pterygotus, by Mr. H. Woodward, 6 plates. The Fossil Brachiopoda, Part VII, No. 3, Silurian, by Mr. Davidson, 15 plates. The Belemnitidæ, Part IV, Liassic and Oolitic Belemnites, by Prof. Phillips, 7 plates. The Reptilia of the Kimmeridge Clay, No. 3, by Prof. Owen, 4 plates. The Pleistocene Mammalia, Part III, Felis spelæa, concluded, with F. lynx, by Messrs. W. Boyd Dawkins and W. A. Sanford, 6 plates.
„ XXIII.*	„ 1869	Supplement to the Fossil Corals, Part II, No. 2, Cretaceous, by Dr. Duncan, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part III, by Dr. Wright, 10 plates. The Belemnitidæ, Part V, Oxford Clay, &c., Belemnites, by Prof. Phillips, 9 plates. The Fishes of the Old Red Sandstone, Part I (concluded), by Messrs. J. Powrie and E. Ray Lankester, 9 plates. The Reptilia of the Liassic Formations, Part II, by Prof. Owen, 4 plates. The Crag Cetacea, No. 1, by Prof. Owen, 5 plates.
„ XXIV.*	„ 1870	The Flora of the Carboniferous Strata, Part II, by Mr. E. W. Binney, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part IV, by Dr. Wright, 10 plates. The Fossil Brachiopoda, Part VII, No. 4, Silurian, by Mr. Davidson, 13 plates. The Eocene Mollusca, Part IV, No. 3, Bivalves, by Mr. S. V. Wood, 5 plates. The Fossil Mammalia of the Mesozoic Formations, by Prof. Owen, 4 plates.
„ XXV*	„ 1871	The Flora of the Carboniferous Strata, Part III, by Mr. E. W. Binney, 6 plates. The Fossil Merostomata, Part III, Pterygotus and Slimonia, by Mr. H. Woodward, 5 plates. Supplement to the Crag Mollusca, Part I (Univalves), by Mr. S. V. Wood, with an Introduction on the Crag District, by Messrs. S. V. Wood, jun., and F. W. Harmer, 7 plates and map. Supplement to the Reptilia of the Wealden (Iguanodon), No. IV, by Prof. Owen, 3 plates The Pleistocene Mammalia, Part IV, Felis pardus, &c., by Messrs W. Boyd Dawkins and W. A. Sanford, 2 plates. The Pleistocene Mammalia, Part V, Ovibos moschatus, by Mr. W. Boyd Dawkins, 5 plates.

* These Volumes are issued in two forms of binding; first, with all the Monographs stitched together and enclosed in one cover; secondly, with each of the Monographs separate, and the whole of the separate parts placed in an envelope. The previous volumes are not in separate parts.

CATALOGUE OF WORKS—Continued.

Vol. XXVI.*	Issued for the Year 1872	Supplement to the Fossil Corals, Part III (Oolitic), by Prof. Duncan, with an Index to the Tertiary and Secondary Species, 7 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part V, by Dr. Wright, 5 plates. The Fossil Merostomata, Part IV (Stylonurus, Eurypterus, Hemiaspis), by Mr. H. Woodward, 10 plates. The Fossil Trigoniæ, No. I, by Dr. Lycett, 9 plates.
„ XXVII*	„ 1873	The Fossil Echinodermata, Cretaceous, Vol I, Part VI, by Dr. Wright, 8 plates. Supplement to the Fossil Brachiopoda, Part I (Tertiary and Cretaceous), by Mr. Davidson, 8 plates. Supplement to the Crag Mollusca, Part II (Bivalves), by Mr. S. V. Wood, 5 plates. Supplement to the Reptilia of the Wealden (Iguanodon), No. V, by Prof. Owen, 2 plates. Supplement to the Reptilia of the Wealden (Hylæochampsa) No. VI, by Prof. Owen. The Fossil Reptilia of the Mesozoic Formations, Part I, by Prof. Owen, 2 plates.
„ XXVIII*	„ 1874	The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr D. Robertson, 16 plates. The Carboniferous Entomostraca, Part I (Cypridinadæ), by Prof. T. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady, 5 plates. The Fossil Trigoniæ No. II, by Dr. Lycett, 10 plates.
„ XXIX*	„ 1875	The Flora of the Carboniferous Strata, Part IV, by Mr. E. W. Binney, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part VII, by Dr. Wright, 10 plates. The Fossil Trigoniæ, No. III, by Dr. Lycett, 8 plates. The Fossil Reptilia of the Mesozoic Formations, Part II, by Prof. Owen, 20 plates.
„ XXX.*	„ 1876	The Carboniferous and Permian Foraminifera (the genus Fusulina excepted), by Mr. H. B. Brady, 12 plates. Supplement to the Fossil Brachiopoda, Part II, No. 1 (Jurassic and Triassic), by Mr. Davidson, 8 plates. Supplement to the Reptilia of the Wealden (Poikilopleuron and Chondrosteosaurus), No. VII, by Prof. Owen, 6 plates.
„ XXXI.*	„ 1877	Supplement to the Eocene Mollusca (Bivalves), by Mr. S. V. Wood, 2 plates. The Fossil Trigoniæ, No. IV, by Dr. Lycett, 13 plates. The Eocene Mollusca (Univalves), Part IV, by Mr. S. V. Wood, 1 plate. The Carboniferous Ganoid Fishes, Part I (Palæoniscidæ), by Dr. Traquair, 7 plates. The Fossil Reptilia of the Mesozoic Formations, Part III, by Prof. Owen, 2 plates. The Fossil Elephants (E. antiquus), Part I, by Prof. Leith Adams, 5 plates.
„ XXXII.	„ 1878	The Fossil Echinodermata, Cretaceous, Vol. I, Part VIII, by Dr. Wright, 8 plates. Index and Title Page to the Fossil Echinodermata, Oolitic, Vol. I (Echinoidea), by Dr. Wright. The Fossil Merostomata, Part V (Neolimulus, &c.), by Dr. H. Woodward, 6 plates. Supplement to the Fossil Brachiopoda, Part II, No. 2 (Jurassic and Triassic), by Mr. Davidson, 13 plates. The Lias Ammonites, Part I, by Dr. Wright, 8 plates. The Sirenoid and Crossopterygian Ganoids, Part I, by Prof. Miall, 6 plates. Supplement to the Reptilia of the Wealden (Goniopholis, Petrosuchus, and Suchosaurus), No. VIII, by Prof. Owen, 6 plates. The Pleistocene Mammalia, Part A (Preliminary Treatise), by Prof. Boyd Dawkins.
„ XXXIII	„ 1879	The Eocene Flora, Part I, by Mr. J. S. Gardner and Baron Ettingshausen, 5 plates. Second Supplement to the Crag Mollusca (Univalves and Bivalves), by Mr. S. V. Wood, 6 plates. The Fossil Trigoniæ, No. V, by Dr. Lycett, 1 plate. The Lias Ammonites, Part II, by Dr. Wright, 10 plates. Supplement to the Reptilia of the Wealden (Goniopholis, Brachydectes, Nannosuchus, Theriosuchus, and Nuthetes), No. IX, by Prof. Owen, 4 plates. The Fossil Elephants (E. primigenius), Part II, by Prof. Leith Adams, 10 plates.

* These Volumes are issued in two forms of binding; first, with all the Monographs stitched together and enclosed in cover; secondly, with each of the Monographs separate, and the whole of the separate parts placed in an envelope.

§ II. LIST OF MONOGRAPHS

Completed, in course of Publication, and in Preparation.

1. MONOGRAPHS which have been COMPLETED, and which may be bound as separate Volumes:—

The Carboniferous and Permian Foraminifera (the genus Fusulina excepted), by Mr. H. B. Brady.
The Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne Edwards and J. Haime.
The Polyzoa of the Crag, by Mr. G. Busk.
The Tertiary Echinodermata, by Professor Forbes.
The Fossil Cirripedes, by Mr. C. Darwin.
The Post-Tertiary Entomostraca, by Mr. G. S. Brady, the Rev. H. W. Crosskey, and Mr. D. Robertson.
The Tertiary Entomostraca, by Prof. T. Rupert Jones.
The Cretaceous Entomostraca, by Prof. T. Rupert Jones.
The Fossil Estheriæ, by Prof. T. Rupert Jones.
The Fossil Merostomata, by Mr. H. Woodward.
The Tertiary, Cretaceous, Oolitic, Liassic, Permian, Carboniferous, Devonian, and Silurian Brachiopoda, by Mr. T. Davidson.
The Eocene Bivalves, Vol. I and Supplement, by Mr. S. V. Wood.
The Eocene Cephalopoda and Univalves, Vol. I, by Mr. F. E. Edwards and Mr. S. V. Wood.
The Mollusca of the Crag, by Mr. S. V. Wood.
Supplement to the Crag Mollusca, by Mr. S. V. Wood.
Second Supplement to the Crag Mollusca, by Mr. S. V. Wood.
The Great Oolite Mollusca, by Professor Morris and Dr. Lycett.
The Trigoniæ, by Dr. Lycett.
The Oolitic Echinoidea, by Dr. Wright.
The Cretaceous (Upper) Cephalopoda, by Mr. D. Sharpe.
The Fossils of the Permian Formation, by Professor King.
The Reptilia of the London Clay (and of the Bracklesham and other Tertiary Beds), by Professors Owen and Bell.
The Reptilia of the Cretaceous, Wealden, and Purbeck Formations, by Professor Owen.
The Fossil Mammalia of the Mesozoic Formations, by Professor Owen.

2. MONOGRAPHS in course of PUBLICATION:*—

The Eocene Flora, by Mr. J. S. Gardner and Baron Ettingshausen.
The Flora of the Carboniferous Formation, by Mr. E. W. Binney.
The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.

* Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

MONOGRAPHS in course of PUBLICATION—*Continued.*

Supplement to the Fossil Corals, by Dr. Duncan.
The Echinodermata of the Oolitic and Cretaceous Formations, by Dr. Wright.
The Carboniferous Entomostraca, by Messrs. T. Rupert Jones, J. W. Kirkby, and G. S. Brady.
The Trilobites of the Mountain-Limestone, Devonian, and Silurian Formations, by Mr. J. W. Salter.*
The Malacostracous Crustacea, by Professor Bell.
Supplement to the Fossil Brachiopoda, by Mr. T. Davidson.
The Ammonites of the Lias, by Dr. Wright.
The Belemnites, by Professor Phillips.†
The Sirenoid and Crossopterygian Ganoids, by Professor Miall.
The Fishes of the Carboniferous Formation, by Prof. Traquair.
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester, and Professor Traquair.
The Reptilia of the Wealden Formation (Supplements), by Professor Owen.
The Reptilia of the Kimmeridge Clay, by Professor Owen.
The Reptilia of the Liassic Formations, by Professor Owen.
The Reptilia of the Mesozoic Formations, by Professor Owen.
The Fossil Elephants, by Prof. Leith Adams.
The Pleistocene Mammalia, by Messrs. Boyd Dawkins and W. A. Sanford.
The Cetacea of the Crag, by Professor Owen.

* Unfinished through the death of the Author, but will be continued by Dr. H. Woodward.
† Unfinished through the death of the Author, but will be continued by Mr. R. Etheridge.

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3. MONOGRAPHS which are in course of PREPARATION:‡—

The Fossil Cycadeæ, by Mr. W. Carruthers.
The Rhizopoda of the Chalk, Chalk Marl, Gault, and Upper Greensand, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.
The Foraminifera of the Lias, by Mr. H. B. Brady.
The Graptolites, by Professor Sir Wyville Thomson.
The Polyzoa of the Chalk Formation, by Mr. G. Busk.
The Palæozoic Polyzoa, by Dr. Duncan.
The Crinoidea, by Professor Sir Wyville Thomson.
Supplement to the Tertiary and Cretaceous Entomostraca, by Prof. T. Rupert Jones.
The Wealden, Purbeck, and Jurassic Entomostraca, by Messrs. T. R. Jones and G. S. Brady.
The Post-Tertiary Mollusca, by Dr. J. Gwyn Jeffreys.
The Cretaceous Mollusca (exclusive of the Brachiopoda), by the Rev. T. Wiltshire.
The Purbeck Mollusca, by Mr. R. Etheridge.
The Inferior Oolite Mollusca, by Mr. R. Etheridge.
The Rhætic Mollusca, by Mr. R. Etheridge.
The Liassic Gasteropoda, by Mr. Ralph Tate.
The Carboniferous Bivalve Mollusca, by Mr. R. Etheridge, junr.

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‡ Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

§ III. Dates of the Issue of the Yearly Volumes of the Palæontographical Society.

The Volume for	1847	was	issued	to the Members,	March, 1848.
,,	1848	,,	,,	,,	July, 1849.
,,	1849	,,	,,	,,	August, 1850.
,,	1850	,,	,,	,,	June, 1851.
,,	1851	,,	,,	,,	June, 1851.
,,	1852	,,	,,	,,	August, 1852.
,,	1853	,,	,,	,,	December, 1853.
,,	1854	,,	,,	,,	May, 1855.
,,	1855	,,	,,	,,	February, 1857.
,,	1856	,,	,,	,,	April, 1858.
,,	1857	,,	,,	,,	November, 1859.
,,	1858	,,	,,	,,	March, 1861.
,,	1859	,,	,,	,,	December, 1861.
,,	1860	,,	,,	,,	May, 1863.
,,	1861	,,	,,	,,	May, 1863.
,,	1862	,,	,,	,,	August, 1864.
,,	1863	,,	,,	,,	June, 1865.
,,	1864	,,	,,	,,	April, 1866.
,,	1865	,,	,,	,,	December, 1866.
,,	1866	,,	,,	,,	June, 1867.
,,	1867	,,	,,	,,	June, 1868.
,,	1868	,,	,,	,,	February, 1869.
,,	1869	,,	,,	,,	January, 1870.
,,	1870	,,	,,	,,	January, 1871.
,,	1871	,,	,,	,,	June, 1872.
,,	1872	,,	,,	,,	October, 1872.
,,	1873	,,	,,	,,	February, 1874.
,,	1874	,,	,,	,,	July, 1874.
,,	1875	,,	,,	,,	December, 1875.
,,	1876	,,	,,	,,	December, 1876.
,,	1877	,,	,,	,,	February, 1877.
,,	1878	,,	,,	,,	March, 1878.
,,	1879	,,	,,	,,	May, 1879.

§ IV. SUMMARY OF THE MONOGRAPHS ISSUED TO THE MEMBERS (*up to* MAY, 1879): *showing in the* FIRST *column whether each Monograph hitherto published be* complete, *or in the* course of completion; *in the* SECOND *column, the yearly volumes which contain each particular Monograph (as a guide to binding the same); and in the* FOURTH *and following columns, the number of pages, plates, figures, and species described in the different Monographs.*

I. SUBJECT OF MONOGRAPH.	II. Dates of the Years *for which* the volume containing the Monograph was issued.	III *m*. Dates of the Years *in which* the Monograph was published.	IV. No. of Pages of Letterpress in each Monograph.	V. No. of Plates in each Monograph.	VI. No. of Lithographed Figures and of Woodcuts.	VII. No. of Species described in the Text.
The Flora of the Eocene Formations, by Mr. J. S. Gardner and Baron Ettingshausen, *in course of completion*	1879	1879	38	5	53	10
The Flora of the Carboniferous Strata, by Mr. E. W. Binney, *in course of completion*	1867, 1870, 1871, 1875	1868, 1871, 1872, 1875	147	24	141	16
The Crag Foraminifera, by Messrs. T Rupert Jones, W. K. Parker, and H. B. Brady, *in course of completion*	1865	1866	78	4	211	43
The Carboniferous and Permian Foraminifera (genus Fusilina excepted), by Mr. H. B. Brady, COMPLETE	1876	1876	166	12	266	62
Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne-Edwards and J. Haime, COMPLETE (*k*)	1849, 1851, 1852, 1853, 1854	1850, 1851, 1852, 1853, 1855	406	72	800	319*g*
Supplement to the Fossil Corals, by Prof. Duncan, *in course of completion*	1865, 1866, 1867, 1868, 1869, 1872	1866, 1867, 1868, 1869, 1870, 1872	232	49	797	149
The Polyzoa of the Crag, by Mr. G. Busk, COMPLETE	1857	1859	145	22	641	122
The Tertiary Echinodermata, by Prof. Forbes, COMPLETE	1852	1852	39	4	144	44
The Oolitic Echinodermata, by Dr. Wright. Vol. I, COMPLETE (*l*)	1855, 1856, 1857, 1858, 1878	1857, 1858, 1859, 1861, 1878	491	43	724	109*h*
„ „ Vol. II, *in course of completion*	1861, 1864	1863, 1866	154	19	218	29
The Cretaceous Echinodermata, by Dr. Wright. Vol. I, *in course of completion*	1862, 1867, 1869, 1870, 1872, 1873, 1875, 1878	1864, 1868, 1870, 1871, 1872, 1874, 1875, 1878	300	76	977	97
The Fossil Cirripedes, by Mr. C. Darwin, COMPLETE	1851, 1854, 1858*a*	1851, 1855, 1861	137	7	320	54
The Fossil Merostomata, by Dr. H. Woodward, COMPLETE	1865, 1868, 1871, 1872, 1878	1866, 1869, 1872, 1872, 1878	265	36	365	51
The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr. D. Robertson, COMPLETE	1874	1874	237	16	515	134
The Tertiary Entomostraca, by Prof. Rupert Jones, COMPLETE	1855	1857	74	6	233	56
The Cretaceous Entomostraca, by Prof. Rupert Jones, COMPLETE	1849	1850	41	7	176	27
The Carboniferous Entomostraca, by Prof. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady, *in course of completion*	1874	1874	56	5	285	50
The Fossil Estheriæ, by Prof. Rupert Jones, COMPLETE	1860	1863	139	5	158	19*i*
The Trilobites of the Mountain-limestone, Devonian, Silurian, and other Formations, by Mr. J. W. Salter (incomplete through the Author's death)	1862, 1863, 1864, 1866	1864, 1865, 1866, 1867	216	31	703	114
The Malacostracous Crustacea (comprising those of the London Clay, Gault, and Greensands), by Prof. T. Bell, *in course of completion*	1856, 1860	1858, 1863	88	22	215	50
Fossil Brachiopoda, Vol. I. The Tertiary, Cretaceous Oolitic, and Liassic Brachiopoda, by Mr. T. Davidson, COMPLETE	1850, 1852, 1853, 1854	1851, 1852, 1853, 1855	409	42	1855	160
„ „ Vol. II. The Permian and Carboniferous Brachiopoda, COMPLETE	1856*d*, 1857, 1858, 1859, 1860	1858, 1859, 1861, 1861, 1863	331	59	1909	157
„ „ Vol. III. The Devonian and Silurian Brachiopoda, COMPLETE	1862, 1863, 1865, 1866, 1868, 1870	1864, 1865, 1866, 1867, 1869, 1871	528	70	2766	321
		CARRIED FORWARD...	4717	636	14,472	2193

I. SUBJECT OF MONOGRAPH.	II. Dates of the Years *for which* the volume containing the Monograph was issued.	III *m*. Dates of the Years *in which* the Monograph was published.	IV. No. of Pages of Letterpress in each Monograph.	V. No. of Plates in each Monograph.	VI. No. of Lithographed Figures and of Woodcuts.	VII. No. of Species described in the Text.
		BROUGHT FORWARD...	4717	636	14,472	2193
Supplement to the Fossil Brachiopoda, by Mr. Davidson, *in course of completion*	1873, 1876, 1878	1874, 1876, 1878	241	29	1,258	170
The Trigoniæ, by Dr. Lycett, COMPLETE	1872, 1874, 1875, 1877, 1879	1872, 1874, 1875, 1877, 1879	246	41	446	115
The Mollusca of the Crag, by Mr. S. V. Wood:—						
Vol. I. (Univalves), COMPLETE	1847, 1855*b*	1848, 1857	216	21	581	244
Vol. II. (Bivalves), COMPLETE	1850, 1853, 1855, 1858*c*	1851, 1853, 1857, 1861	344	31	691	253
Supplements to the Crag Mollusca, No. I and II, by Mr. S. V. Wood, COMPLETE	1871, 1873, 1879	1872, 1874, 1879	322	18	517	232
The Eocene Mollusca, Cephalopoda and Univalves, by Mr. F. E. Edwards, continued by Mr. S. V. Wood. Vol. I, COMPLETE	1848, 1852, 1854, 1855, 1858, 1877	1849, 1852, 1855, 1857, 1861, 1877	361	34	625	275
The Eocene Mollusca, Bivalves, by Mr. S. V. Wood. Vol. I, COMPLETE	1859, 1862, 1870	1861, 1864, 1871	182	25	531	194
Supplement to the Eocene Mollusca, by Mr. S. V. Wood (Bivalves). Vol. I, COMPLETE	1877	1877	24	2	66	30
The Great Oolite Mollusca, by Prof. Morris and Dr. Lycett, COMPLETE	1850, 1853, 1854	1850, 1853, 1855	282	30	846	419
„ „ „ Supplement by Dr. Lycett, COMPLETE	1861	1863	129	15	337	194
The Liassic Ammonites, by Dr. Wright, *in course of completion*	1878, 1879	1878, 1879	164	18	101	0
The Belemnites, by Prof. Phillips, *in course of completion*	1863, 1864, 1866, 1868, 1869	1865, 1866, 1867, 1869, 1870	128	36	622	69
The Upper Cretaceous Cephalopoda, by Mr. D. Sharpe, COMPLETE	1853, 1854, 1855	1853, 1855, 1857	67	27	319	79
The Fossils of the Permian Formation, by Prof. King, COMPLETE	1849, 1851*e*	1850, 1855	287	29	511	138
The Sirenoid Ganoids, by Prof. Miall, *in course of completion*	1878	1878	32	6	61	6
The Fishes of the Carboniferous Formation, by Dr. Traquair, *in course of completion*	1877	1877	60	7	58	5
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester, *in course of completion*	1867, 1869	1868, 1870	62	14	195	21
The Reptilia of the London Clay [and of the Bracklesham and other Tertiary Beds], by Profs. Owen and Bell, COMPLETE ‡	1848, 1849, 1856*f*	1849, 1850, 1859	150	58	304	39
The Reptilia of the Cretaceous Formations, by Prof. Owen, COMPLETE‡	1851, 1857, 1858, 1862	1851, 1859, 1861, 1864	184	59	519	26
The Reptilia of the Wealden and Purbeck Formations, by Prof. Owen, COMPLETE ‡	1853, 1854, 1855, 1856, 1857, 1858, 1862	1853, 1855, 1857, 1858, 1859, 1861, 1864	155	62	251	17
The Reptilia of the Wealden Formations (Supplements) *in course of completion*	1871, 1873, 1876, 1878, 1879	1872, 1874, 1876, 1878, 1879	81	21	175	15
The Reptilia of the Kimmeridge Clay Formation, by Prof. Owen, *in course of completion*	1859, 1860, 1868	1861, 1863, 1869	16	6	23	3
The Reptilia of the Liassic Formations, by Prof. Owen, *in course of completion*	1859,‖ 1860,‖ 1863, 1869	1861, 1863, 1865, 1870	121	37	177	8
The Reptilia of the Mesozoic Formations, by Prof. Owen, *in course of completion*	1873, 1875, 1877	1874, 1875, 1877	97	24	165	17
The Crag Cetacea, by Prof. Owen, *in course of completion*	1869	1870	40	5	43	7
The Fossil Elephants, by Prof. Leith Adams, *in course of completion*	1877, 1879	1877, 1879	146	15	123	2
The Pleistocene Mammalia, by Messrs. W. Boyd Dawkins and Mr. W. A. Sanford, *in course of completion*	1864, 1867, 1868, 1871, 1878	1866, 1868, 1869, 1872, 1878	304	32	253	7
The Mammalia of the Mesozoic Formations, by Prof. Owen, COMPLETE	1870	1871	115	4	247	30
		TOTAL.....	9273	1342	24,517	4808

a Index. *b* Title-page to Univalves. *c* Note to Crag Mollusca. *d* Contains the Permian. *e* Two corrections of Plates. *f* Supplement.
g Many of the species are described, but not figured. *h* British species only reckoned. *i* British species only reckoned. *k* A Supplement is now in course of publication.
l Index will be found in 1878 vol. *m* Useful for establishing the dates of new species.
‡ Title-pages and Index will be found in the 1864 Volume, or may be had separately. ‖ Marked on outside label 'Reptilia of Oolitic Formations.'

§ V. STRATIGRAPHICAL TABLE *exhibiting the* BRITISH FOSSILS *already figured and described in the* ANNUAL VOLUMES (1847—1879) *of the* PALÆONTOGRAPHICAL SOCIETY.

	PLANTS.	PROTOZOA.		RADIATA.		ARTICULATA.					
		Sponges.	Foraminifera.	Corals.	Echinodermata.	Cirripedes.	Cypridæ, Cytherinæ, &c.	Estheriæ.	Merostomata.	Trilobites.	Malacostracous Crustacea.
Pleistocene	...	...	...	...	.....	.....	1874				
Crag	...	...	1865	1849	1852	1851, 1854					
Eocene	1879	...	...	1849, 1865	1852	1851, 1854	1855	...	.....	.....	1856
Cretaceous.....	...	...	...	1849, 1868, 1869	1862, 1867, 1869, 1870, 1872, 1873, 1875, 1878	1851, 1854	1849	...	.....	.....	1860
Wealden	...	...	...	...	.....	.....	...	1860			
Oolitic	...	...	...	1851, 1872	1855, 1856, 1857, 1858, 1861, 1878,	1851	...	1860			
Liassic	...	...	...	1851, 1866, 1867	1855, 1856, 1858, 1861, 1864						
Triassic	...	...	...	...	.....	.....	...	1860			
Permian	1849	1849	1849, 1876	1849, 1852	1849	.....	1849	1860			
Carboniferous...	1867, 1870, 1871, 1875	...	1876	1852	.....	.....	1874	1860	1872, 1878		
Devonian	...	...	...	1853	.....	.....	...	1860	1865, 1868, 1872, 1878	1862	
Silurian.....	...	...	...	1854	.....	.....	...	...	1868, 1871, 1872, 1878	1862, 1863, 1864, 1866	
Cambrian	...	...	...	...	.....	.....	...	...	.....	1864	

NOTE.—The numbers in the above List refer to the Volumes issued for those Dates.

STRATIGRAPHICAL TABLE *exhibiting the* BRITISH FOSSILS *already figured and described in the* ANNUAL VOLUMES (1847—1879) *of the* PALÆONTOGRAPHICAL SOCIETY (*continued*).

	MOLLUSCA.				VERTEBRATA.		
	Polyzoa.	Brachiopoda.	Monomyaria, Dimyaria, and Gasteropoda.	Cephalopoda.	Fishes.	Reptiles.	Mammalia.
Pleistocene	...	1873	.....	...	...	.....	1864, 1867, 1868, 1871, 1877, 1878, 1879
Crag	1857	1852, 1873, 1879	1847, 1850, 1853, 1855, 1871, 1873, 1879	...	...	.....	1869
Eocene	...	1852, 1873	1852, 1854, 1855, 1858, 1859, 1862, 1870, 1877	1848	...	1848, 1849, 1856	
Cretaceous.....	...	1852, 1854, 1873	1872, 1875, 1877, 1879	1853, 1854, 1855	...	1851, 1857, 1858, 1862	
Wealden	...	... ..	.....	...	...	1853, 1854, 1855, 1856, 1857, 1862, 1871, 1873, 1875, 1876, 1878, 1879	
Oolitic	...	1850, 1852, 1876, 1878,	1850, 1853, 1854, 1872, 1874, 1875, 1877, 1879	1850, 1861, 1868, 1869	...	(Purbeck) 1853, 1858 (Kim. Clay), 1859, 1860, 1868, 1873, 1875, 1877 (Great Oolite) 1875	1870
Liassic	...	1850, 1852, 1876, 1878	1874, 1877, 1879	1863, 1864, 1866, 1868, 1878, 1879	...	1859, 1860, 1863, 1869, 1873	
Triassic.....	...	1876, 1878	1879	.....	1878	.....	1870
Permian	1849	1849, 1856	1849	1849	1849	1849	
Carboniferous ...	...	1856, 1857, 1858, 1859, 1860	.....	.....	1877		
Devonian	...	1862, 1863	.....	.....	1867, 1869		
Silurian.....	...	1865, 1866, 1868, 1870					
Cambrian							

NOTE.—The numbers in the above List refer to the Volumes issued for those Dates.

THE

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MDCCCLXXIX.

A MONOGRAPH

OF THE

BRITISH EOCENE FLORA.

BY

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AND

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PART I.

FILICES.

Pages 1—38; Plates I—V.

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A MONOGRAPH

ON THE

BRITISH EOCENE FLORA.

INTRODUCTION.

Although for many years no additions have been made to our knowledge of the British Eocene floras, in published works, yet during that period material has been rapidly and steadily accumulating. When, ten years since, my attention was first directed to the fossil leaves which were then found abundantly at Bournemouth, the extent of the Eocene flora hidden there was not even surmised. It had been stated, in fact, to contain but few types. The fossil leaves of Alum Bay, however, were well known, especially to Mr. Keeping, who had fully ascertained that no very great variety of forms were to be found there. In addition to these, fossil floras were also referred to as having been collected from Studland and the neighbourhood of Corfe.[1] From the London Basin there were known the Eocene Fruits of Sheppey, and scanty floras from Reading and Dulwich, and from the outlier of the Hampshire Basin at Newhaven. At the present day, however, owing to further collecting, we have available a whole series of extensive floras, commencing from that of the Woolwich and Reading beds upwards, embracing the Oldhaven beds, the London Clay, the Lower Bagshot, the Middle Bagshot, and the Upper Eocenes; in fact, from almost every stage of the Eocenes known to occur in this country. This magnificent series of floras of consecutive, and in most cases absolutely defined, age has as yet no parallel in any other country. Its contemplation gives rise to problems, the direction and tendency of which are so unmistakable that, in following the facts as recorded in the succeeding pages, they will be apparent to the student.

I will first call attention to a few examples of the kind of problems which await solution, and then refer to the value of the determinations of the plant-remains described in this work.

[1] For references, see page 1, *et seq.*

Beginning with the *Woolwich and Reading Beds,* we have a flora, very limited in extent, and consisting of a few, but apparently persistent types, which have a temperate facies. It would be interesting if this could be proved to be a fragment of a flora descended from the oldest indigenous dicotyledonous flora of the European or Eastern-Atlantic area, before the Eocene temperature had been raised by causes about which I have elsewhere hazarded some speculations.[1]

The next British Eocene flora, second in age and supposed to belong to the *Oldhaven Beds,* has quite another character, as far as we can judge from the present materials. A small collection only has been made; but, by systematic work, results may be looked for not surpassed by those obtained at Bournemouth. These materials seem to indicate a relation to the Eocene floras of Sézanne. The same types, and the same luxuriant preponderance of serrate dicotyledonous leaves, are characteristic of both. It would almost seem that we have here another really indigenous, but somewhat more sub-tropical, European flora, without the Australian or American types, which later on so very considerably modified it.

In America we have, though possibly belonging to a far removed age, just such another purely indigenous flora in the so-called Cretaceous *Dakota Beds.* These floras, which are perfectly distinct from each other, seem to belong to a period antecedent to the connection of Europe and America, although the rise of the afterwards connecting land was probably, I think, even then gradually raising the temperature by shutting off more and more completely the Arctic currents from the Atlantic. As at Sézanne, there appears to be an absence of those Australian forms, especially the *Proteaceæ,* which became so abundant at a later Eocene time. Saporta shows that in the so-called Cretaceous and Eocene European floras, wherever European types are present, the Australian element, or, at least, the *Proteaceæ,* are almost excluded, and that the reverse is equally the case.[2] But the presence or absence of Australian forms is known in so many localities where they occur, in an apparently arbitrary manner, which cannot be accounted for either by difference of soil or climate, that the thought arises whether it may not be possible that the relative ages of the isolated floras on the Continent have been wrongly inferred. Instead of appearing and disappearing frequently, did not the members of the Australian flora, like those of the American at a later date, come in, in the way newly introduced species are now seen to do when climatic conditions are favorable? The Australian type of plants had a great and sudden extension until

[1] 'Nature,' December 12th, 1878, p. 124.

[2] With regard to Sézanne, however, it may be urged that there are reasons why leaves of *Proteaceæ* should not be found. The flora is evidently that of a shady, moist, and luxuriantly woody valley. The leaves are found in a tufaceous matrix, and must have fallen from overhanging trees and adhered to the sides of a ravine, wet, probably, with the spray of an adjacent waterfall charged with carbonate of lime. Under such conditions travertine rocks are formed rapidly and enclose masses of leaves, as we see at Tivoli, for instance, at the present day. It is, perhaps, unlikely, therefore, that *Proteaceæ,* which generally have a dry habitat, even if abounding contemporaneously, would be preserved under such circumstances.

displaced by the American flora. If so, the floras without *Proteaceæ* may, in the absence of other evidence, be looked upon as the more ancient; and we should fix, in some measure, the date of the arrival of that Australian element whose presence in Europe, when discovered and described, caused so much surprise.

The flora of the *London Clay*, unlike that of other stages, which are represented by leaves principally, is known from seeds and fruits. I am indisposed at present to speculate upon its affinities, since there is a possibility of obtaining leaves from the *Basement Bed*. I will merely say that fruits belonging to the same genera, but specifically different, are found in the *Middle Bagshot Beds*, and that Heer believes the Sheppey fruits and the Alum-Bay leaves belong to the same plants.

The Alum-Bay flora, of *Lower Bagshot* age, has been so well explored that it is rare, even after long work, to discover any form in it that is new. It abounds with what are generally accepted as Proteaceous leaves, and yet these are mingled with larger leaves of Figs, Laurels, Leguminous plants, and the lobed leaves of Aralias, Maples, &c., representing a luxuriant flora which did not grow on sterile ground, or in a very dry climate. It is a good example of the Australian type of an Eocene flora, and is most distinct in England from those above and below it.

The newer *Bournemouth* flora, assigned in this work to the *Middle Bagshot* stage, appears to be separated from the last by a great interval of time, for the flora seems almost wholly American, and, singular to say, the small Pliocene flora of California, described by Lesquereux, more resembles it generically, though the species are different, than does any other known to me. In it the *Proteaceæ* are replaced by the American *Myricaceæ*, and it seems to contain a number of existing American genera not previously recognised among fossils.

If these tentative speculations, founded at present on somewhat superficial knowledge, have any basis of truth, they would show that it was between the Lower and Middle Bagshot periods that North America and Europe were connected by land. The floras of the Upper Eocene merge gradually, without further striking change, into those of the Miocene, whose story has been so often and so ably traced by Heer.

Although all these floras are here spoken of as strikingly disconnected, it must not be supposed they are absolutely so; on the contrary, not a few forms are common to many, and some may be found in all of them.

As the British Eocene floras become better known through the progress of our work these speculations may receive confirmation or be altogether set aside. I have, however, ventured to put them forward, as they may invest the study with an interest beyond that which the mere description and determination of the Plants alone would possess.

The singularly little attention as yet bestowed upon this subject in England has been doubtless primarily due to the difficulty in satisfactorily determining the fossils. These floras, mainly composed of detached dicotyledonous leaves, present such exceptional difficulties that even when very great thought and care have been bestowed upon the

work, the correctness of the results may yet be open to doubt. No author has written upon similar floras without expressing his opinion of the magnitude of these difficulties. Yet, many seem to have forgotten, during the progress of their work, the caution they insisted on at its commencement. Nothing is more easy than to assign generic and specific names to leaf-forms; but, with such material, the determinations are so much a matter of opinion that criticism or contradiction is useless.

The publication, however, of careful drawings of fossil plants is of value; and were the determinations which have been made even more doubtful and provisional in character than they are at present thought to be, it is, nevertheless, a real benefit to science to accurately figure and describe all the obviously different leaves and fruits that have been discovered. Many fossil leaves fade, others crack and peel off from the matrix; dust can never be completely removed, and necessarily obscures the more delicate venation; indeed, these characters are so easily obliterated that without exceptional care the specimens soon become valueless. Fossil fruits are from other causes equally difficult of preservation. Unfortunately leaves formerly collected in quantity from Corfe, Branksea, Dulwich, and many other places, are no longer to be obtained from these localities; and almost all of the few specimens still in existence have become so obscure that they give very imperfect evidence of the nature of these floras. Thus, links in the history of plant-life are lost, perhaps beyond recovery.

As long ago as 1854, Edward Forbes, in his Anniversary Address[1] to the Geological Society, called attention to the necessity of doing something with these floras.

"Were all known fragments of distinct vegetables found in our Tertiaries monographed and named in the manner of those I shall have presently to mention, described and figured in the lately published memoirs by Austrian Botanists, our lists would be considerably increased. They certainly ought to be made the subject of a treatise, and might be advantageously taken up by the Palæontographical Society, which, as yet, has given no separate memoir on British fossil plants."

It is to be greatly regretted that no practical steps have hitherto been taken to accomplish this work, as, since Professor Forbes made this suggestion, instances have come under my own notice in which whole beds of leaves have been either carried away by the sea, or quarried out, or deeply buried under refuse.

It seems likely that the cautions formerly reiterated by such distinguished men as Hooker, Charles Bunbury, and E. Forbes himself, intended to direct investigation, have had the practical effect of discouraging British palæontologists from undertaking it, since the only writings of importance upon our British Tertiary floras are, with the exception of Bowerbank's description of the fossil fruits of the London Clay, by foreigners. Botanists when consulted have very often, unintentionally no doubt, deterred collectors from taking any further interest in fossil leaf-forms by the emphatic stress they have laid upon the variation to which leaves belonging to the same species of plant are subject,

[1] 'Quart. Journ. Geol. Soc.,' vol. x, p. lvi.

and upon plants widely separated in a natural classification having the same form of leaf. Intending students have been led to think that leaves may not be separated into species when they are dissimilar in form, nor united in one when similar. Surely, however, it does not follow that, because the task is difficult, nothing should be attempted. Apart from their determination, if we regard leaves merely as signs, and are indifferent, for instance, as to whether they belong to Oak, or Beech, or Elm, or to common ancestors of these, they still possess much interest, since frequently on their evidence alone the date of many a volcanic eruption, change of level, or silting up of lakes, has to be fixed. Even in our own country, we see that the volcanic outbursts of Mull and the North of Ireland, and the lake-system at Bovey-Tracey, have been determined to be of Miocene age entirely on plant evidence.

However great the difficulties may be in determining these fossil plants from the isolated organs which alone for the most part we possess, the task is certainly not altogether hopeless. Fortunately we are not wholly dependent upon leaves, but have large series of fruits and seeds as well, and even occasional flowers to assist us. Were we, therefore, to find leaves which, although seemingly of Oaks, for example, but which might be leaves of other and widely separate families, we should hesitate how to class them; but if we find that acorns had been floated down by the same river which brought the leaves, our doubts would be greatly removed. With the increasing stock of knowledge such results may be hopefully looked for. But even where we have nothing but detached leaves to deal with, much may be done. Many plants can be recognised by the form of the leaves, still more by the venation, and their determination is more certain when the texture is preserved. The latter is of great importance; for instance, the leaves of a species of Nettle and of a Cinnamon have the same venation and form, yet owing to the difference in their texture they could, even if fossil, hardly be mistaken. Texture, however, although indicated in the fossil, cannot always be reproduced in the illustrations. Even the leaves of those plants which vary much can generally be recognised, if a large series be examined, by their venation, though in outline they may be quite dissimilar. The question is not, however, whether some plants so vary that it is impossible to determine them from their leaves, but it would be important to determine whether the species of the living genera to which these fossils have been referred are so variable. The habit of collecting and attentively examining fossils from deposits of one age, if extended over many years, induces so great a familiarity with their peculiarities of texture and aspect that they become easily recognisable by minor differences, which would escape even a botanical specialist who passed them under examination for the first time. Again, considerable advantage is gained by attending to the general assemblage of plants in a fossil flora. As an instance, we find at Bournemouth a leaf, hitherto supposed to be that of a *Castanea*, associated abundantly and almost exclusively with Palms and Ferns of tropical American type. The correctness of the determination appears doubtful, since we have no precedent for such a grouping, whereas a species

of *Godoya* even more nearly resembles the Bournemouth leaf, and its presence might be expected in such company. The large series of the same forms of leaves which I have brought together thus greatly facilitate their determination. The limits of variation in many given leaf-forms can be recognised; leaves which would be included as varieties, if found singly, are seen to be persistent in their form. Gradually the work becomes easier; to-day we have but isolated leaves; to-morrow a chance brings to light an associated fruit or flower, a branchlet of leaves, showing their attachment—some clue by which conjecture is rendered almost certainty.

In arriving at our decisions respecting the comparative ages of isolated floras, besides taking into consideration those differences which are likely to be present when they are widely separated, either by latitude or longitude, we must make allowance for local causes, which influence and even change the character of neighbouring floras at the present day. These are so well known that it is only necessary to allude to them here. Plant-remains from argillaceous, and arenaceous soils would more or less differ. Limestones, serpentine, and basalts have characteristic plants. Peat and soil impregnated with saline matters nourish plants that are markedly dissimilar. Local differences in climate, such as are caused by the prevalence of certain winds, excess of moisture, proximity to mountain ranges, or to sea-currents of different temperatures, exert a powerful influence on vegetation. Difference of altitude, it is well known, makes almost as much change in each foot vertically as in miles horizontally. Some of these conditions have no doubt modified the floras to be described.

As plants of the Tertiary period are found in a more and more extended area, we see that very frequently leaves, evidently of the same species, have been placed by authors in many, and sometimes widely, different genera. As knowledge increases, such differences will in due course become corrected. Free interchange of ideas, and, where possible, of specimens before final publication, would obviate much of this burdensome synonomy in the future. It would also be more dignified and satisfactory were authors of species themselves from time to time to disclaim those which had become synonyms or were founded on insufficient characters or data, instead of leaving others, not in so good a position, to make the corrections. Eventually it is to be hoped that Botanists, who have made especial orders of living plants their study, following the example so well set by Mr. Hiern in his 'Monograph of the Ebenaceæ,' may be tempted to devote themselves to a critical examination of the determinations hitherto made, so that the immense importance of Plant Remains, which exceeds in many respects that of Animal Remains, may be eventually conceded to them.

Notwithstanding their importance, no section of Palæontology has been more neglected by our fellow-countrymen than the plants of the Tertiary Period. The floras of our older rocks are familiar to us by the works of Lindley, Hutton, Williamson, Binney, Carruthers, and others. Phillips has given us a considerable insight into the nature of the British Jurassic flora; but from Oolitic times plant-history is still, so far as this

country is concerned, comparatively a blank. It is true that for long ages we have but the scantiest remains to tell us how vegetation progressed in this area, and the subject, until Tertiary times are reached, from its very meagreness, has offered few attractions to its research. Such materials as have been brought to light have been investigated by Carruthers, who has published in a series of papers as much as there is known respecting British Cretaceous floras. The vast fresh-water deposits of the Wealden, in which, from analogy, we should have expected to find series of plant-remains important in the history of evolution, have yielded little else but Ferns, Cycads, and Conifers. The Neocomian flora appears to have been similar. The marine beds of our Cretaceous rocks have from top to bottom yielded only a few isolated remains of Conifers, which had probably been drifted out to sea. No remains whatever of Dicotyledons have been found in them; and a few rolled pellets of wood, with a palm-like structure, are the only traces of Monocotyledons which they anywhere present.

I have elsewhere[1] spoken of the immense gap in the geological record which exists in England between our Uppermost Chalk and our Lowest Eocene, completely severing the plant-life of the latter period from all that preceded it. If we turn to other countries we see that this gap is but partially filled up, for it is still doubtful whether any of the foreign Cretaceous beds containing Dicotyledons were contemporaneous even with our Chalk, our highest member of the series.

From nearly the commencement of our Eocenes, on the contrary, almost every section has been found to contain more or less extensive series of plant-remains, forming a striking contrast, from their abundance and variety, to the remains found in beds preceding them. Although this has long been familiar to English Botanists and Geologists, the only attempts to describe English Eocene plants, so far as I know, have, with few exceptions, been on a very limited scale. These are hereafter noticed in detail in their stratigraphical and chronological order.

The nearly unbroken sequence seen in the Eocene floras extends into the Miocene. There is no great break in passing from one to the other when we compare them over many latitudes, and but little change beyond that brought about by altered temperature or migration. But if Tertiary floras of different ages are met with in one area, great changes on the contrary are seen, and these are mainly due to progressive modifications in climate, and to altered distribution of land. From Middle Eocene to Miocene the heat imperceptibly diminished. Imperceptibly, too, the tropical members of the flora disappeared; that is to say, they migrated, for most of their types, I think, actually survive at the present day, many but very slightly altered. Then the sub-tropical members decreased, and the temperate forms, never quite absent even in the Middle Eocenes, preponderated. As decreasing temperature drove the tropical forms south, the more northern must have pressed closely upon them. The Northern Eocene, or the temperate floras of that period, must have pushed, from their home in the far north,

[1] 'The Popular Science Review,' January, 1879, p. 55.

more and more south as climates chilled, and at last, in the Miocene time, occupied our latitudes. The relative preponderance of these elements, I believe, will assist in determining the age of Tertiary deposits in Europe, more than any minute comparisons of species. Thus it is useless to seek in the Arctic Regions for Eocene floras, as we know them in our latitudes, for during the Tertiary period the climatic conditions of the earth did not permit their growth there. Arctic fossil floras of temperate, and therefore Miocene aspect, are in all probability of Eocene age, and what has been recognised in them as a newer or Miocene facies is due to their having been first studied in Europe in latitudes which only became fitted for them in Miocene times.

When stratigraphical evidence is absent or inconclusive, this unexpected persistence of plant types or species throughout the Tertiaries should be remembered, and the degrees of latitude in which they are found should be well considered before conclusions are published respecting their relative age.

FLORA

OF THE

BRITISH EOCENE FORMATIONS.

I. Flora of the Thanet Sand.

Very little is known of the flora of this earliest Eocene Period of England, and there is some doubt as to the exact age of even the few plant-remains which have been described as belonging to it.

In the second volume of Lindley and Hutton's 'Fossil Flora,' 1833-5, is a figure[1] of a Cone, described as *Zamia macrocephala*, and in the third volume, another called *Zamia ovata*.[2] These were supposed to be Cretaceous, but they are now known to be from the Thanet Sands. One is from near Deal, the other from Faversham. Additional material having been discovered, these species were examined and redescribed by Carruthers, in the 'Geological Magazine' for 1866,[3] as *Pinites macrocephalus* and *P. ovatus*. In 1870 Carruthers read a paper[4] on *Osmundites Dowkeri*, a fossil fern-stem from Herne Bay, and in 1872 Thiselton Dyer[5] described fossil wood from the same locality. Coniferous wood has also been found, Professor Morris informs me, at Richborough in Kent.

II. Flora of the Woolwich and Reading Beds.

The earliest notice of the occurrence of plants in these strata is to be found in Webster's paper[6] "On the Strata lying over the Chalk," published in 1814. To Warburton belongs the credit of having first discovered the remains of fossil leaves at Newhaven. They were mentioned in subsequent papers, and in 1817 Sowerby gave a figure[7] of the prevailing leaf, which, he conjectured, might be near to *Platanus orientalis*. Mantell in 1822[8] held the same opinion when he figured the same species with some additional forms.

In 1854, Prestwich figured and Hooker described a number of leaves and other vegetable remains from Reading and from Counter Hill;[9] but Hooker declined to hazard

[1] Pl. 125, p. 117.
[2] Pl. 226, p. 189.
[3] Vol. iii, Pls. 20, 21, p. 534.
[4] 'Quart. Journ. Geol. Soc.,' vol. xxvi, p. 349, pls. 24 and 25; 'Geol. Mag.,' vol. ix, p. 52.
[5] 'Geol. Mag.,' vol. ix, p. 52.
[6] 'Trans. Geol. Soc.,' vol. ii, p. 191.
[7] 'British Mineralogy,' vol. v, p. 185, pl. 500.
[8] Mantell, 'Geol. Sussex,' pl. 8, p. 262.
[9] 'Quart. Journ. Geol. Soc.,' vol. x, pp. 88 and 163, pl. 4.

any determinations upon the very insufficient materials. Shortly after appeared a note by Hooker [1] on *Carpolithes ovulum* from Lewisham, which he supposed was the sporangium of a cryptogamous plant; but this opinion has not been adopted by recent writers, who consider it the seed of a Nymphaceous plant.[2] De-la-Harpe [3] considered that the Reading leaves might be determined, and in 1856 referred them to various genera.

In the table of fossils from these beds in the fourth volume of the 'Geological Survey Memoirs,' p. 578, six of these leaves have specific names attached to them.

In 1875 Rupert Jones and Cooper King [4] noticed fragments of leaf-beds enclosed in strata in a newly exposed section at Reading.

A most careful search there has resulted up to the present in nothing more than indistinct leaf-remains, principally of Willow form.

Mr. E. S. Dewick informs me that a bed of leaves was cut through fourteen years since by a railway excavation at Mottingham, and has forwarded me the small fragments that were preserved. Other leaf-remains have been found at Charlton.

Very few of the plant-remains from the Woolwich and Reading Beds are now in a condition to be of value for descriptive purposes; but some, sufficiently well preserved, exist in the British, Jermyn Street, and the Geological Society's Museums, and I possess a series from Dulwich, which were formerly in Bowerbank's collection. In addition to this, in 1878 I obtained from Newhaven a considerable number of leaves in a beautiful state of preservation. This I esteem the more fortunate, since the leaf-bed is very local and has almost entirely fallen into the sea, whither it will be followed at no distant date by the rest of the outlier. I shall therefore be able to give an account, though very imperfect, of this Lower-Eocene flora. Little diversity seems its chief feature, for the greater part of the leaves found by Mantell, Prestwich, and myself, belong to a small number of species. An Aralia-like leaf has been found at Lewisham. I have not seen any remains of the palms mentioned as coming from the formation, or the cone figured by Prestwich (l. c.), and I fear they may now be disintegrated.

III. Flora of the Oldhaven Beds.

Whitaker [5] mentions plant-remains in these beds from several localities. The most important is at Widmore Kiln, Bromley. Some leaves from that place were submitted to Carruthers, who remarked upon them as follows:—"The series of leaves

[1] 'Quart. Journ. Geol. Soc.,' vol. xi, pl. xvi, p. 562.
[2] Schimper, 'Traité de Pal.,' vol. iii, p. 93.
[3] 'Bull. Soc. Vaudoise,' vol. v, p. 123.
[4] 'Quart. Journ. Geol. Soc.,' vol. xxxi, p. 451.
[5] 'Mem. Geol. Surv.,' vol. iv, 1872, pp. 247, 582.

contain two well-marked types, which have been almost invariably recognised as belonging to *Ficus* and *Cinnamomum*. The carbonised wood is *coniferous*."

This flora differs materially from that of Alum Bay, and from that of Newhaven, and perhaps more nearly resembles the Bournemouth flora than either of them. It is remarkable that the leaves are usually found adhering to a stem, instead of being detached, as is generally the case elsewhere.

IV. Flora of the London Clay.

The *Fossil Fruits* of Sheppey have been known for two centuries at least. They occur in abundance in the beds between Sheerness and Warden Point, and are washed out with other organic fragments and cement-stones, and gathered on the beach as copperas. The people engaged in collecting the copperas and cement-stones have for years been accustomed to set aside the more defined specimens; but, unfortunately, the fruits were perishable, and, with few exceptions, have disintegrated in a very short time.

The earliest notice of them, according to Whitaker's list of works on the London Basin,[1] is an anonymous 'Fossiliæ Sheppeianæ Catalogus "[2] of 1709. The next, 1757, is a paper by Dr. J. Parsons,[3] in which forty-four varieties of fruits are figured. They were thought to be Figs, Myrobalan, Phaseolus, seeds of an American Gourd, Coffee-berries, Pods of the Underground Pea, small Melon, Acorn, Plum-stone, Cherry-stone, berry of Sapindus, fruit of Hura, Mango, Horse-chestnut, Cocoa-nut, &c.

The author thought that if they were antediluvian they would, in some measure, point out the time of year in which the deluge began, which could not have been in May, as supposed by Dr. Woodward, but, from the ripeness of the fruits, in autumn.

In 1777 E. Jacob, in an Appendix to the 'Plantæ Favershamienses,' gives a list of fossil plants from Sheppey, under the heads of Lignum fossile, Equisetum, Fructus varii Aristæ, and Mycetidæ.

In 1811 Parkinson[4] figured several fruits from Sheppey, but added nothing to Parson's list, except the suggestion that Nipadites was probably the fruit of the genus Cocos.

In 1814 Webster[5] wrote that the cliffs of Sheppey had long been celebrated, and that from them, with the beds at Faversham and Emsworth, 700 different species of fossil fruits were known. In 1828 Brongniart, in his 'Prodrome des Végétaux Fossiles,' describes three fruits from Sheppey, to which he gives the names of *Cocos Parkinsonii*,

[1] 'Mem. Geol. Surv.,' vol. iv.

[2] 'Monthly Miscellany,' vol. iii, p. 163.

[3] 'Phil. Trans.,' vol. l, p. 396, pl. vi.

[4] 'Organic Remains, &c.,' vol. i, pls. vi and vii.

[5] 'Trans. Geol. Soc.,' ser. I, vol. ii, p. 2. The information appears to have been derived from a MS. Catalogue (now in the British Museum), by Francis Crow, of Faversham, dated 1810, illustrated with 831 drawings, supposed by the author to represent about 700 varieties.

Amomocarpum depressum, and *Pandanocarpum pyramidatum*, and adds that many undetermined species of Carpolithes occur there. In 1832 Lindley and Hutton, in the list of fossil plants, prefixed to the first volume of the 'Fossil Flora,'[1] include the species of Brongniart, with some additional forms based on portions of plants, as Palmacites, Flabellaria, Caulinites, Equisetum, and Fucoides.

In 1840 Bowerbank commenced a 'History of the Fossil Fruits and Seeds of the London Clay,' which was to be completed in five parts. The first part was published, but the second part, although announced as in preparation, never appeared. The illustrations, by J. de C. Sowerby, are particularly well drawn. The descriptions of *Nipaditis* are remarkably accurate, and the correctness of the author's approximation of them to *Nipa* has stood the test of time. Not so, however, the thirteen species into which the author divides them, it being now considered that few of these can be maintained. The author seems throughout to have made too many species. It was supposed that the fruits had been floated from a warmer clime; but Heer, in 1845, pointed out that the leaves found at Alum Bay belonged to similar groups. Herne Bay and other localities, in addition to Sheppey, have yielded fossil fruits; and resin, besides fossil wood, has frequently been met with at Highgate. The impressions of leaves have been found in the Basement-Bed of the London Clay at Barnet's End, near Hemel Hempstead.[2] I regret that I have not been able to see these plants, which, if well preserved, are of extreme interest.

Ettingshausen has entirely devoted four months' stay in London, made in connection with our work, to a preliminary examination of the Sheppey fruits, and he is already able to announce the presence of the following genera:—*Pinus*, *Callitris*, *Salisburia*; *Musa*, *Sabal*, *Elais*, *Iriartea*, *Livistona*, *Oenocarpus*; *Quercus*, *Liquidambar*, *Nyssa*, *Diospyros*, *Symplocos*, *Magnolia*, *Juglans*, *Eucalyptus*, *Amygdalus*, *Bauhinia*. He further recognises three genera of palms, which he is unable yet to determine, and several new and interesting fruits belonging to Apocynaceæ, Cinchonaceæ, Cucurbitaceæ, &c.

V. Flora of the Bagshot Formation.

The plants of these beds form, when united, by far the most extensive and varied fossil flora, of approximately one age, brought together from any single country. In treating of their Bibliography it will save repetition to consider them as one.

The leaf-impressions from Alum Bay have been known for a long time, for the first mention of them which I have met alludes to them as already familiar to geologists. The first published reference of these remains to any group of plants was by the

[1] 'Foss. Flora of Great Britain,' vol. i, p. xliii.

[2] 'Mem. Geol. Surv.,' vol. iv, p. 586.

Rev. W. B. Clarke,[1] in 1839, when he described a lignitic bed as composed of "relics of aquatic plants and the bark and seed-vessels of Pine." The Rev. P. B. Brodie first announced that fossil leaves in clay were to be found to the east of Bournemouth.[2] These he supposed to belong to Lauraceæ and Amentaceæ, to Characeæ and other Cryptogams. In 1844 Mantell[3] noticed them, and adopts Brodie's views; again in 1847,[4] he mentioned the occurrence at Bournemouth "of the same species of plants as those found in Alum Bay." In 1849 Prestwich[5] fixed the relative position of the Bournemouth and Alum Bay leaf-beds, and recorded the finding of leaves, although of few species, west of Bournemouth. In 1850 Dixon's 'Geology of Sussex' appeared, in which a few plant-remains were figured from Bracklesham. Two were identified as *Lycopodites squamatus* and *Cucumites variabilis*, and the third was called *Pinites Dixoni*. There were also figured some very beautiful sections of palm-stems picked up on the beach near Worthing and Shoreham.[6]

In 1851 Mantell,[7] who was evidently himself acquainted with the Bournemouth leaf-beds, introduced some notes on the "Foliage of Dicotyledonous Trees," from "thin layers of sandy clay in the cliffs west of Bournemouth." All the leaves were dicotyledonous, and appeared to him to have been shed. Many he still considered referable to Lauraceæ and Amentaceæ, and some he referred more specially to species of Willow, Poplar, and Laburnum. In another of his works[8] we find a foot-note stating that, while the vegetable remains from the Isle of Sheppey are tropical in character, those from Bournemouth, Alum Bay, and Newhaven, are of a temperate climate, *e.g.*, Nerium and Platanus, whence Edward Forbes inferred that in the former case they were transported from distant lands by currents, and the latter were the true flora of the country.

In 1853 the Rev. P. B. Brodie[9] noticed the occurrence, at Corfe, of elytra of Coleopterous Insects belonging to the families Curculionidæ and Buprestidæ. A Date-palm and a species of Willow are also mentioned by him as having been obtained from the neighbourhood of Corfe; and he further states that a larger number of plants had been procured in different parts of the series, appearing to belong to distinct natural orders. In 1854, according to Prestwich,[10] there were only three species of plants

[1] 'Mag. Nat. Hist.,' ser. ii, vol. iii, p. 438.

[2] 'Proc. Geol. Soc.,' vol. iii, p. 592.

[3] 'Medals of Creation,' vol. i, p. 193.

[4] 'Geol. Isle of Wight,' p. 169.

[5] 'Quart. Journ. Geol. Soc.,' vol. v, p. 43.

[6] The exact age of the rolled palm-wood is unknown, but it may be derived from Eocene below the London Clay.

[7] 'Geological Excursion round the Isle of Wight,' 2nd edition, Supplement.

[8] 'Fossils of the British Museum,' 1851, p. 51.

[9] 'Quart. Journ. Geol. Soc.,' vol. ix, p. 53.

[10] 'Quart. Journ. Geol. Soc.,' vol. x, p. 75.

known in the Bracklesham flora. In the same year the elytra of four Beetles were figured by Westwood ;[1] and Ruegg [2] mentions that the delicate leaf-impressions from the Dorsetshire pipe-clays belong for the most part to the natural order Salicineæ.

Nothing further was published until 1856, when the first attempt to give a general description of these floras, and to determine their species, was made by De-la-Harpe.[3] Some 300 specimens were got together from all the known collections. From Alum Bay alone 200 were examined, all being either in the possession of the Geological Survey, Bowerbank, or Prestwich. Of the Alum Bay flora 48 species were recognised and 43 determined ; 13 of these were said to be common to Bournemouth, 7 to Corfe Castle, 3 to Reading, and 26 peculiar to itself. A Maple and a Poplar were abundant in individuals. Figs and Laurels are represented by many species ; the largest leaf is that of a Walnut. Two or three Banksias are common ; but the most abundant in species and individuals are the Leguminosæ, which, he remarks, are absent at Bournemouth and Corfe.

For the Bournemouth Flora there was only a small number of specimens in the Geological Survey Museum. Twenty-two species were, however, recognised, 13 common to Alum Bay, 5 to Corfe, 1 to Counter Hill ; all were dicotyledonous, except a small parasitic Fungus. The species in the same Museum obtained at Corfe were identified, 7 as common to Alum Bay, and 5 to Bournemouth. De-la-Harpe enters into comparisons of the floras, and bases upon them conclusions which were, perhaps, justified by the imperfect materials then at his command.

In 1859 Heer,[4] supposing the age of the Alum Bay leaf-bed to be the same as that of the Barton Clay, alludes to them as "Upper Eocene." His trained perception led him to detect the connection between the Alum Bay and the Sheppey floras. The leaves of *Apeibopsis*, De-la-Harpe, are, he says, "perhaps from the same tree whose fruit Bowerbank named *Cucumites variabilis*.[5] At Bournemouth leaves are found, apparently of *Cupania*, which may, perhaps, be combined with the fruit of *Cupanoides*." The flora more particularly resembles that of Monte Bolca, 9 species out of 40 being considered to be common to both.

In 1862 the Geological Survey published a 'Memoir on the Isle of Wight,' in which all the then determined fossil leaves and fruits from Alum Bay were tabulated (pp. 121, &c.) and 21 species figured (pls. 5, 6, and 7), and described by De-la-Harpe (pp. 109, &c.). This, the most important work hitherto brought out on the subject, was left in the hands of De-la-Harpe, Salter having no responsibility in this portion of the work. In the first introductory sentence by Salter the fossil floras of Bournemouth, Corfe, and

[1] 'Quart. Journ. Geol. Soc.,' vol. x, p. 381, pl. xvi, figs. 34, 35 ; also pl. xiv, figs. 4 and 8, see 'Geol. Mag.,' vol. vii, p. 348.

[2] 'Journ. Roy. Agric. Soc.,' vol. xv, p. 394.

[3] 'Bull. de la Société Vaudoise des Sciences Naturelles,' 1856.

[4] 'Flora Tertiaria Helvetiæ,' vol. iii, p. 314.

[5] 'Flor. Tert. Helv.,' vol. iii, p. 314.

Alum Bay, are said to be "identical," and a little further on these places are said to be "on exactly the same horizon," although their relative positions had long previously been pointed out by Prestwich and others. The determinations and correlations are very incorrect, probably from the specimens being mixed, since of 22 species from Bournemouth, 13 are said to be identical with those of Alum Bay; but we now know that none of the characteristic forms are common to both horizons. Palms are said to be met with only at Corfe; yet two species are included in the list of fossils from Alum Bay, in the body of the work, at p. 42. This memoir does not include any species not published in De-la-Harpe's previous work; an *addendum* contains a rough list from Heer of the genera found in the Miocene of Oeningen, which has no apparent connection with the subject.

In 1865 W. S. Mitchell,[1] who for some time previously had been working at the Lower and Middle Bagshot Beds, figured a species of *Porana*, which he provisionally named *P. Vectensis*. He also noticed various new leaves, to which, however, he declined to attach either generic or specific names. In 1866[2] he again announced the discovery of further leaf-forms at Alum Bay, without offering any opinion as to the number of species obtained. Some 470 specimens had been collected, and drawings of some were exhibited to the British Association.[3] Two years later G. Maw[4] expressed the opinion that the *Porana* of Mitchell, and another flower-like form from Studland, resemble *Kydia* more than *Porana*. In 1869[5] A. Wanklyn described fragments of a *Gleichenia* from Bournemouth, for which he proposed a new genus and two species. In 1870 Mansell-Pleydell[6] noticed the occurrence of plant-remains at Alum Bay, Studland, &c., especially mentioning *Gleichenia* and *Sabal*.

From this time little has been written except the few brief notices in which I have quite recently called attention to the unexpected extent of the Bagshot floras of Hampshire and Dorsetshire. These will be found in the 'Reports of Conferences held in connection with the Loan Collection of Scientific Apparatus in 1876, Section of Physical Geography, &c.,' p. 412; in the text of a lecture given in the latter part of 1876, at the South Kensington Museum;[7] in a paper read before the "Geologists' Association," January 5th, 1877, published in the fifth volume of their 'Proceedings;' in subsequent papers in 'Nature,'[8] and in an article in the 'Popular Science Review' for July, 1878.

In Prof. Rupert Jones's second edition of Dixon's 'Geology of Sussex,' 1878, p. 162,

[1] 'Geol. Mag.,' vol. ii (1865), p. 516, figs. 1—3.
[2] 'Geol. Mag.,' vol. iii (1866), 476.
[3] 'Report Brit. Assoc.,' 1866, p. 146.
[4] 'Geol. Mag.,' vol. v (1868), p. 74.
[5] 'Ann. and Mag. Nat. Hist.,' ser. iv, vol. iii, p. 10, pl. i.
[6] 'Flora of Dorset.'
[7] 'Nature,' January 11th, 1877, and following week.
[8] March 29th, August 9th, November 15th, 1877, &c..

&c., Carruthers determines the plant-remains mentioned by the original authors as *Pinites Dixoni*, Bowerb., *Pinites Bowerbanki*, Carr., fragment of a Coniferous twig, *Cedroxylon Worthingense*, Carr., *Palmacites Dixoni*, Carr., *Palmacites constrictus*, Carr, *Palmacites oblongus*, Carr., *Carpolites Dixoni*, Carr., and Dicotyledonous Wood.

§ 1. The Lower-Bagshot Flora.—Next to that from Sheppey this is the most widely known of the English Eocene Floras. It has attracted considerable attention, partly perhaps on account of the beds being conspicuously exposed and easily accessible at Alum Bay. In the pipe-clay bed which occurs there we have an exceedingly well-preserved and beautiful, as well as extensive, flora. The leaves, almost always detached, are flat and smooth, and appear to have belonged principally to deciduous forest-trees. The species are not abundant, compared with the number of specimens. The distinctive character of the flora is due to the size and variety of the leaves ascribed to the genus Ficus and to the Leguminosæ, in a scarcely less degree to a deeply cleft palmate Aralia, a trilobed leaf resembling Liquidambar, a deeply serrate Banksia, and other leaves referred to Comptonia, Dryandra, and Myrica. Few, if any, of these have been found in the Middle Bagshot division at Bournemouth. The inference that the Studland beds were of the same geological age as those of Alum Bay has been confirmed, many of the characteristic Alum Bay leaves having lately been found there, including the Aralia and Liquidambar. The Studland flora, however, has a somewhat different character; for although all the dicotyledons are identical, they are in the minority, and their leaves are bent and mingled with masses of broken fronds of large Fan-palms and Ferns; whilst many Insect wing-cases and Shells have been met with implying, as I believe, greater proximity to land. Mitchell informs me that leaves in good preservation were formerly found in the clay-pits at Brankscа Island, of this age, but no record of their forms is preserved. Splendid specimens used to be obtained abundantly from the Corfe pits, but time and dust have so obliterated the smaller leaves that have been preserved as to render them valueless for purposes of identification. Fragments of Fan-palms in various Museums, and some large-lobed leaves in the Museum at Oxford, are almost the only well-marked specimens still remaining. Repeated search in these pits of late years has only brought to light a few leaves of simple form, without distinct venation. No record of the forms of the leaves discovered in pipe-clay at Newbury exists as far as I know.[1] The Lower-Bagshot flora appears to possess such very distinctive characters that we may be enabled safely to compare it with European fossil floras, and so to fix their horizon.

§ 2. The Middle-Bagshot Flora.—This appears to be far more extensive and more varied than that of the Lower Bagshot beds, although less known, collecting having been hitherto confined to the cliffs close to Bournemouth. Leaves, flowers, and

[1] 'Memoirs of the Geol. Survey,' vol. iv, p. 312.

fruits occur there in very small basins; to the number of these which have now been explored, and to the fact that each basin contains a large proportion of plants peculiar to itself, are due the extent and richness of the material at our disposal. The western portion of the cliff-section presents us with the older beds, and these contain principally leaves of dicotyledonous forest-trees; the central area, adjoining Bournemouth Pier, abounds in Palms, Ferns, &c.; while to the east we see marsh- or swamp-vegetation, and finally fruits, seeds, and branches, which have been floated out to sea. Commencing from the west, we find, at less than half a mile from the rise of the cliffs, some small patches of clay with a few leaves peculiar to them; the first flora of importance, however, is contained principally in two basins. The more westerly was the richer of the two, but is now inaccessible, if not completely lost, from a heavy landslip. It was characterised by the number of branches with leaves attached, that it contained. The trees were mainly dicotyledonous, and, I believe, largely evergreen. Palms have not been observed, but a climbing Lygodium is prevalent. A large pinnatifid leaf, resembling Stenocarpus, is confined to this bed. The occurrence of leaves attached to branches, of Insect remains, and of a feather, seems to indicate proximity to the shore. The second basin contains scarcely anything but quantities of single and very perfect leaves, resembling those of a large Hornbeam or Beech, which are spread in layers. The next bed is a little to the east, and contains a great variety of small Willow-like leaves, with entire and serrate margins. It is remarkable that, where any of the species found in other beds are met with in this, they are seen to be stunted or dwarfed. My interpretation of these facts is that the western beds present a comparatively upland flora, the leaves found in the first basins having been shed from luxuriant forests, and those in the latter from trees or bushes which grew in a more barren tract.

The next beds are in the immediate neighbourhood of Bournemouth. Approaching from the west, the first leaf-bed is a mass of compact dark clay. The uppermost layers contain some indistinct leaf-impressions, then we meet with large pinnate leaves of Palms, crossing each other in all directions;[1] and under these a bed of leaves, the prevailing form being a Myrica, not elsewhere met with at Bournemouth. The next bed contains many especially characteristic plants; among them being the Gleichenia, whose fronds occupy a layer by themselves, large pinnate leaves of a Palm, which appear to me to resemble Iriartea more than any other genus, and a Castanea-like leaf (Godoya?), the only one met with at Bournemouth. The succeeding beds under the Coastguard Station consist of seven or eight layers, separated from each other by coarse quartz grit, and each characterised by a group of leaves more or less peculiar to it. Several of the rarer Ferns, both pinnate and palmate leaves of Palms, and some of the most important dicotyledons, were obtained from them. One layer contains hardly anything but leaves of a small Ficus. The uppermost bed, a dark-black clay, is full of the pinnæ of *Osmunda*

[1] A portion of one extracted measured four feet in length by three feet in breadth.

lignitum, Cactus spines, and branchlets of a Sequoia-like Conifer, and recalls most forcibly, by its aspect, by the identity of its fossils, and by the manner of their occurrence, some of the beds at Bovey-Tracey. We seem to have in these central beds the remains of a luxuriant and tropical valley vegetation.

Beyond the Pier a bed contains Ferns, Aroids, Fan-palms, and a Eucalyptus, and with these a Sequoia-like Conifer, which from the complete absence everywhere of cones, the similarity of foliage, and the association of plants, may, perhaps, be referred to the swamp-loving Podocarpus or Dacrydium. The last fresh-water beds met with contain the remarkable forms referred to the Polypodiaceæ. They are associated with other Ferns, Rushes, and the Conifer already mentioned, and indicate a swamp-vegetation. Thus, by the plants may be traced the change from hill to valley and from valley to marsh.

In the *Marine Beds* are found numerous fruits, seeds, fragments of Conifers, Cactus, &c. The fruits and seeds, although comparatively few in number, are a valuable discovery, being from a higher horizon than the leaf-patches. They appear, like those from Bracklesham, to be related to the fruits from Sheppey, which are found in the London Clay, and therefore below the leaves. About sixteen kinds have been collected, including, it is supposed, Nipadites, Hightea, Cucumites, and Petrophiloides, sufficient to establish that no great break took place in the flora as a whole. The assistance of the Sheppey fruits may thus be important in determining the genera of the Bagshot leaves and flowers; for, even with a slight connection established, we should, in cases where leaves might be referred to different genera, get data for selecting a particular genus from the Sheppey fruits. These determinations may thus have a value which botanists refuse to them when based on leaves alone.

The Flora of Bovey-Tracey.—It may appear strange to find the flora of Bovey-Tracey, thought to be typically Miocene, included in that of the Middle Bagshot. It is, however, perfectly clear to me that the Bovey-Tracey beds are on the same horizon as those at Bournemouth, from which they are some eighty miles distant. Even in this first section upon Ferns it will be seen that there are elements common to both, for two of the three are common to Bournemouth; and, while one is equally rare at both places, another is equally abundant at both, and found under precisely similar conditions. The detached pinnæ of *Osmunda lignitum* are found in blackish shaly clay, spread in layers mingled with Cactus spines and Sequoia, exactly as they are at Bournemouth; and so identical are they in appearance that, were the specimens mixed, it would be impossible to tell which belonged to either locality. The third Fern found at Bovey is a common Eocene form. Of other plants, the Cactus (*Palmacites Dæmonorops*, Heer) is found abundantly in certain beds at Bournemouth and Bovey, and scarcely anywhere else. The fruits are so similar that handfuls of Anona, for instance, from each place, if once mixed, could not again be separated. The Cinnamons of Bovey, thought to be so characteristic of the Miocene, are most abundant everywhere at Bournemouth. The Oaks, the Laurels,

the Figs, in fact nearly, if not quite all the Dicotyledonous leaves are identical, so that the Bournemouth flora itself must be Miocene if that of Bovey be Miocene. Were a minority of the plants, instead of a majority, common to both, it would not be surprising, seeing that neighbouring patches at Bournemouth differ much more considerably in their contents from each other than does the Bovey-Tracey flora, as a whole, from that of Bournemouth; and we could therefore hardly have expected to find, especially taking into consideration the variety and richness of the Middle-Bagshot flora, an exactly similar assemblage of plants so far removed from each other and growing, perhaps, at a different level. The Bovey flora, according to Heer, bears the greatest resemblance to that of Monosque among French Tertiary Floras, of whose Eocene age I entertain no doubt, for it is the one bearing the greatest relationship to these Middle Bagshot beds. The three small seeds which are supposed to link Bovey with Hempstead are, in my opinion, insignificant, and, indeed, are not confined to that section of the Eocene. The subject might be pursued further, but the progress of this work may be left to show the correctness of my views respecting the age of these beds.

When Heer wrote[1] in 1861 it must be remembered that no Eocene floras of any extent had been described, and scarcely any material existed for comparison, except what was of Miocene age. The fossil flora of Bournemouth was a sealed book, and many Eocene floras on the Continent were then thought to be Miocene, so that in making comparisons error was certain to be introduced. He was also, no doubt, influenced by the Alum-Bay plants, which hardly resemble those of Bovey, and probably somewhat by the preconceived opinions of English geologists. It appears to me that in the then state of knowledge regarding these Tertiary Floras he could scarcely avoid classing the Bovey beds with the Miocene.

As the specimens from Bovey-Tracey were described by Heer in the 'Philosophical Transactions' for 1862, it is not proposed to refer further to them except in so far as the materials here worked up modify the views of the original describer.

§ 3. The Upper-Bagshot Flora.—No plants whatever have been hitherto described from beds of this age. I have extracted from some of the lignites at Barton fragments of Fir-cones and indistinct seeds, and some similar remains are to be found in the Woodwardian Museum, Cambridge.

VI. The Upper Eocene Floras.

§ 1. The Headon Flora.—No plants have been recorded from the Headon beds, except three species of Chara, *Carpolithes ovulum*, and *Folliculites thalictroides*.[2] *Palma-*

[1] 'Phil. Transact.,' 1862, part ii, published in 1863.

[2] Bristow, 'Mem. Geol. Surv.,' 1862.

cites Lamanonis, the woodcut of which has so frequently been introduced by Mantell in his various works, may be from this stage. Fortunately, however, Henry Keeping, in 1876, came across several fine specimens of a Feather-palm at Hordwell, now in the Woodwardian Museum. I have since seen large ironstone concretions at Hordwell traversed by similar leaves.

§ 2. The Bembridge Flora.—Nothing but some fruits of Characeæ[1] had been noticed from these beds; I have, however, seen branches of Conifers and seeds in the Bembridge Marls, at Hempstead. J. A'Court Smith has recently collected an extensive flora from Gurnet Bay, including, as he informs me, a large series of Dicotyledons, Palms, &c.

§ 3. The Hempstead Flora.—This flora was partially known to Lindley and Hutton in 1832, who alluded to it in the preface to their work, as the "Upper Fresh-water Formation." Nymphæa and Zosterites are the only fossils mentioned by them as occurring in it. Edward Forbes in 1852[2] separated and described the Hempstead Beds. In 1856[3] he again described them, and mentions Typha-like leaves, *Taxites Parisiensis*, three species of Chara, and *Folliculites thalictroides* as occurring in them. In 1862[4] a second species of *Folliculites* was added to the list. In 1862 Heer[5] described and figured the then known Hempstead flora, ten species in all. In 1863 Heer, in 'The Lignite Formation of Bovey-Tracey,' by Pengelly and himself, described four species common to the two localities.

Although the greater part of this flora is composed of seeds and mere fragments of reed-like plants, beautiful leaves of Nelumbium and a small Fan-palm have been found.

BRITISH EOCENE FERNS.

The objections to the determination of dicotyledonous leaves apply with considerably less weight to those based upon Fern fronds. Where these, however, are fragmentary and no trace of fructification is present, there is still great uncertainty, for a number of existing genera include species that have the most varied venation. It is fortunate that many of the Ferns described in the present work have been determined either from very numerous, or exceptionally well-preserved specimens. We therefore believe that, notwithstanding the difficulties arising from the well-known tendency of certain Ferns to

[1] 'Mem. Geol. Survey, Isle of Wight,' 1862.
[2] 'Quart. Journ. Geol. Soc.,' vol. ix.
[3] 'Mem. Geol. Survey, Isle of Wight,' 1856, p. 44.
[4] Bristow, 'Mem. Geol. Surv., Isle of Wight,' 1862.
[5] 'Quart. Journ. Geol. Soc.,' vol. xviii, p. 369.

variation in the form of their fronds, and even in the angles and relative proximity of the venules, errors or unnecessary multiplication of species have been avoided. Nearly all the specimens from Bournemouth, whence they were chiefly procured, seem to have been macerated so as to disconnect the pinnæ and remove the spores.

Ferns are relatively rare in British Eocenes, and yet some twenty distinct forms are described in this Monograph. The floras consist principally of deciduous dicotyledonous leaves, which, in the ordinary course of events, fell into the water and were tranquilly silted over. Ferns, on the other hand, would require some violence to remove them from the place of their growth, and their preservation would consequently be exceptional, and they would be mutilated and fragmentary. This may account for their rarity.

Few as these British forms are in the number of species, they nevertheless form the largest and most important series of Eocene, even of Tertiary Ferns, yet described from any one group of beds.

Although our knowledge of the Ferns which existed in Tertiary times is still most imperfect, yet we find that nearly all of them have allied living representatives, although none of these now live in the British Isles. So close, in fact, are the resemblances in many cases, that it is difficult to avoid the belief that they are the more or less direct descendants of the fossil forms; indeed, some Continental authors, think that in the Miocenes of Switzerland the directly intervening forms can be traced.

A few of the genera here described belong to groups which have not previously been found fossil; but many of them are Eocene forms already described. It is interesting to find that some of these, like a few living species, ranged synchronously over both hemispheres, as a few are also found fossil in North America.

One of the most remarkable, and a very abundant form, is a *Chrysodium*, which ranges from the Alum-Bay beds at Studland, through the Lower-Bournemouth series, into the overlying marine beds, and has a no less wide range upon the Continent. The *Polypodieæ* with reticulated venation are represented by at least three species; numbers of specimens of each having been obtained. Their venation is somewhat abnormal, in one instance approaching so nearly to that of dicotyledons as to leave considerable doubt in my mind as to its determination. The *Pterideæ* are represented by several species, the most abundant of which is closely allied to many Eocene and Miocene forms already known. Another, of which we have only a fragment, is related to a group with reticulated venation now living in Polynesia. A third is hardly distinguishable from the widely distributed Miocene *P. Œningensis*. A unique specimen is doubtfully referred to the *Asplenaceæ*. The *Aspidiaceæ* have three representatives, one of which possesses a new type of venation, somewhat resembling that of certain dicotyledons, and has been placed by Ettingshausen in a new genus. The others are referred to *Phegopteris*, and resembles living forms. *Gleichenia*, well known in Cretaceous times, has only been met with in admittedly Eocene strata at Bournemouth, where it is represented by a trailing or climbing form, of most local and limited distribution. The

Schizæaceæ are represented by a *Lygodium* allied to the recent *L. palmatum*, and identical with a species from the Eocene Lignitic Series of America. In this Fern the fertile fronds have also been met with. A species of *Aneimia* is very abundant and beautifully preserved at Bournemouth, and is also common to the Eocenes of America and Sézanne, and possibly Aix-la-Chapelle. The most prevalent form, however, is *Osmunda lignitum*, which is equally abundant at Bovey-Tracey, and of which *O. Dowkeri*, Carr., may possibly be the stem. Of the other Ferns figured, one, if not two, certainly belongs to *Adiantum*; and there are others upon which no determination can be hazarded.

The Ferns seem to throw some light upon the physical condition and gradual depression of the land in the Eocene period. At Bournemouth the lower beds, met with towards Poole, are supposed to contain a wooded and more or less hillside flora, and Ferns are there represented only by a climbing *Lygodium*. In the beds further east, near the Pier, which contain a more luxuriant vegetation, we find the delicate *Gleichenia*, both species of *Phegopteris*, and *Osmunda*. These, I believe, required a warm, moist, shady situation. We next find the large *Chrysodium*, *Osmunda*, *Meniphyllum*, and *Pteris*, mingled with masses of Aroids, &c., which would require a still more moist habitat. Finally, in the most eastern and newest beds of the freshwater series, we meet with masses of *Polypodieæ*, which probably grew at the sea-level in company with a decidedly swamp vegetation.

Of all the Ferns described, only four were previously known as British, and two of these were supposed to be from the Miocene. Three were known from the American Eocene, four from the Aquitanian and Tongrian stages of Western Europe, and one from Sézanne; the rest are new. In addition to these, there are several other Ferns, which are too indistinct to be figured.

Von Ettingshausen, in his work on Tertiary plants, has found it necessary to invent a distinct terminology for Ferns.[1] His explanation of the types of venation, and the terms he distinguishes them by, so far as he employs them in the present work, will be useful here.

"The simplest venation in Ferns is the *Hyphopteris* (fig. 1), in which each division of the frond is traversed by only one vein.

"When the veins, and consequently also the divisions of the frond, are arranged in a compact pinnate or pectinate order, then the *Hyphopteris* type becomes the *Craspedopteris* (fig. 2). In this case the rachis may be regarded as the midrib or primary vein, and the midribs as secondary veins. This applies more particularly to the *Craspedopteris vera*, where the secondary veins are mostly connected by parenchyma. When the veins are disconnected, except at their base, it becomes *Craspedopteris Ctenodes, e.g. Polybotrya Lechleriana*, Mett.; Ett., 'Farnkr.,' Pl. xiii, figs. 5, 6, &c.

[1] 'Die Farnkräuten der Jeztwelt,' Vienna, 1865.

" In most Ferns, however, the divisions of the frond are traversed by several or many veins. When they are forked primary veins, diverging from each other in a radiate manner, and equal, or the central one more prominent, the venation is *Cyclopteris* (fig. 3). This is divided into several types, of which I will explain the *C. simplex æqualis*, the *C. simplex inæqualis*, and the *C. composita*. In the first the primary veins are symmetrically disposed, forming only forked branches (*ex. Adiantum*); in the second the primary veins are nearly all on one side of the division, or unsymmetrically dispersed; and in the last the primary veins send out secondary ones, as in *Lygodium*.

Fig. 1.—Hyphopteris.

Fig. 2.—Craspedopteris.

" In all other kinds of venation of Ferns, each ultimate division has only one primary vein (the midrib or costa) from which the secondary ones spring, and the latter frequently give rise to ternary veins.

" The primary vein rarely reaches the apex of the pinnule in *Neuropteris* (fig. 4), but disappears in a number of forked branches, and the secondary veins are given off from it at very sharp angles, diverging in curves towards the margin, so that their marginal branches constantly form more obtuse angles with the primary vein than their stems. Among the

Fig. 3.—Cyclopteris.

Fig. 4.—Neuropteris.

types of this kind of venation we notice the *Neuropteris vera;* here the midrib is invariably dissolved, and usually at an appreciable distance from the apex, and the dichotomously branched secondary veins diverge very much. In *N. acrostichacea* the primary vein is prolonged almost close to the apex, or even reaches it; and the secondary veins are only once or twice forked, and are less divergent (*ex. Pteris cocænica*, &c.).

"This last type comes near that of *Tæniopteris* (fig. 7), in which, however, the midrib is very much elongated, the secondary veins exceedingly numerous, given off at right, or not very acute angles, and never divergent, but either convergent (towards the midrib) or rectilineal.

"In the *Alethopteris* type (fig. 5) the midrib is slender, and gives off short rectilineal or slightly convergently curved secondary veins at acute angles; ternary veins are wanting, or only proceed from the lowest secondary ones, and only on one side (of the pinnule).

FIG. 5.—Alethopteris.

FIG. 6.—Pecopteris.

"In the *Pecopteris* type (fig. 6) the undivided or forked secondary veins spring from the midrib, which is distinctly continued to the apex, at slightly acute angles, and send out ternary veins (*ex. Gleichenia Hantonensis* and *Osmunda lignitum*).

"Whereas in the foregoing types of venation all the veins are free, in the following some or all of them anastomose with each other. Those of the *Goniopteris* type (fig. 8) all anastomose, or at least the inner ternary veins, and remain undivided. The two anastomosing veins blend in one called the ray, which runs through in the *Goniopteris-*

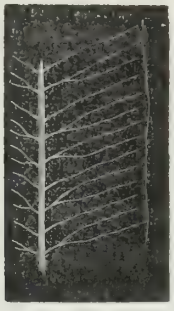


FIG. 7.—Tæniopteris.

FIG. 8.—Goniopteris.

Aspidii type, that is to say, it extends to the point of union of the next pair, whilst in the *Goniopteris Meniscii* type (*Phegopteris præ-cuspidata*; Pl. IV, fig. 9) they terminate before reaching the union. All the ternary veins are united in the latter type, but in that of *G. Aspidii* (*Phegopteris Bunburii*, Pl. V) some of them are free.

"When the ternary veins form a network in which there is a row of larger meshes on either side of the midrib or secondary veins, we have the *Dictyopteris* type. In this either all the veins are connected in a network (*D. simplex*), or the secondary ones are

looped, curved, or marginal, and only the ternary one netted (*D. composita*). The secondary and ternary veins are remarkably shortened in the former, and scarcely, or not distinctly, separated from each other. The meshes of the network enclose free venules or not, and are accordingly *D. appendiculata* or *D. exappendiculata* (*Chrysodium Lanzæanum*).

"Finally, there are the *Phlebodium* (fig. 9) and *Drynaria* (fig. 10) types of venation belonging to the group with anastomosing veins. In the former the very much abbreviated secondary veins form, by a peculiar anastomosis of their forked branches, a prominent row of larger long meshes on each side of the midrib, and several rows of loops. In the *Drynaria* type the anastomosing ternary veins are given off in a pinnate manner from both sides of

FIG. 9.—Phlebodium.

FIG. 10.—Drynaria.

the elongated secondary ones, which are strongly curved or looped. The rays or appendages within the ternary meshes anastomose in such a manner as to form a network resembling the venation of dicotyledonous leaves. The meshes usually enclose free venules. When the ternary segments are regularly rhomboid or elongated, it is the *Drynaria regularis* type; when these segments are indistinctly outlined and of irregular shape, they belong to the *D. irregularis* type (*Glossochlamys transmutans*, Pl. III, fig. 3), and when the secondary veins form neither curves nor loops, but terminate in the margin, combining with the marginal ones, they compose the *Drynaria composita* type, a type at present confined to the fossil genus *Meniphyllum*."

CRYPTOGAMÆ.

Order.—FILICES.

Sub-order.—POLYPODIACEÆ.

(a.) *Acrostichaceæ.*

Chrysodium Lanzæanum (*Visiani*). Plate I and Plate II, figs. 1—4.

Fortisia Lanzæana, *Visiani.* Piante fossili della Dalmazia, p. 11, pl. 1, fig. 8; pl. 2, figs. 1 and 5.

Ch. fronde coriacea pinnata, pinnis lanceolatis vel oblongo-lanceolatis, acuminatis, margine undulatis vel integerrimis, basi sessilibus, mediis et inferioribus semi-amplexicaulibus, subdecurrentibus, superioribus attenuatis; nervatione Dictyopteridis simplicis exappendiculatæ; nervo primario pervalido, rigido, prominente; nervis secundariis angulis acutis variis egredientibus, congestis, abbreviatis, dictyodromis; maculis oblongis, prominentibus, pluriseriatis.

Lower Bagshot, Studland; Middle Bagshot, Bournemouth; Upper Eocene, Hordwell.

The remains are those of a large Fern closely allied to the existing wide-spread tropical *Chrysodium vulgare*, Fée. The thick carbonised substance of the frond figured in Pl. I indicates its former coriaceous texture. The pinnæ are lanceolate, and are so closely seated on the rachis, which is 8 mm. in diameter, that their margins overlap. They seem to have varied in the form of the base from cuneate to semi-amplexicaul, according to their position on the rachis, and to the size and development of the frond: thus, those represented in Pl. I have a broadly amplexicaul, almost decurrent base, and are from the middle of a frond; whilst in Pl. II, fig. 2, a pinna is seen with an almost acute base, and is therefore supposed to have been derived from the upper part of a frond. A somewhat similar variation, but in a much less degree, is seen in the bases of the pinnæ of *Ch. vulgare*, which are, however, never amplexicaul, but always stipitate. The apex is pointed; the margin undulate. In venation it also approaches *Ch. vulgare*, differing slightly only in the greater divergence of the angles at which the secondary veins start, and in the greater diversity of form presented by the meshes of the network.

Numerous short, contiguous, intricately anastomosing, fine veins proceed from a prominent midrib, at angles more acute on the less developed pinnæ towards the apex of the frond (Pl. II, fig. 2), than those of the middle and base. The limits of the divergence observed in the angles are 20° and 60°. The short secondary veins are as close together as in *Ch. vulgare*. In length and shape the meshes vary from rectangular to narrow-lanceolate or linear; sometimes, as Pl. II, fig. 4, from Studland, not anastomosing throughout their entire length. In *Ch. vulgare* the range of variation, in this as in other respects, is more circumscribed.

The fossil, while closely resembling the recent *Ch. vulgare*, seems to have been more variable in its growth, and differed principally in the more amplexicaul attachment of the pinnæ.

Chrysodium Lanzæanum was described in 1858 by Visiani from the Eocene of Monte Promina as *Fortisia*, a genus which he founded for this and a closely allied species. In 1877 Saporta announced the discovery of a *Chrysodium* from the Aquitanian beds of Manosque in Provence:[1]—"Je ne puis m'empêcher de signaler * * * un très beau *Chrysodium*, genre d'acrostichées, dont une espèce encore inédite, recueillie aux environs de Manosque, se rattache directement aux formes les plus nettement tropicales." This *Chrysodium* from Manosque, of which numerous pinnæ are preserved on the surface of a large slab, is nearly allied, Saporta informs me, like the Bournemouth plant, to *Ch. vulgare;* but the pinnæ are narrower, more lanceolate, and with a more acute and attenuated apex, and the whole plant appears to have been more slender; resembling in these respects the Hordwell specimens. He therefore thinks that the two can hardly be identified as a single species. It is remarkable that it was there associated with *Lastræa Stiriaca*, *Osmunda lignitum*, and *Lygodium Gaudini*, as at Bournemouth and Bovey-Tracey, and that with these also occur at Manosque species of Pteris allied to those of Bournemouth, *Pteris pennæformis* and *P. urophylla*, the latter only a variety of *P. Œningensis*. There is thus seen to be a considerable resemblance in the Ferns from the two localities, which are supposed to differ in age sufficiently to account for the slightly varying specific characters. Remains of

Fig. 11.—Chrysodium vulgare.

[1] 'La Nature, Revue des Sciences,' 5 année, No. 224, p. 245, 15th September, 1877.

Chrysodium have quite recently been met with by Saporta in the Gypsum of Aix, from which more than 300 forms of plants have been collected. This undescribed species has been minutely compared by Saporta with specimens of the Bournemouth *Chrysodium*, and he pronounces them to be specifically the same, although the Aix specimens are somewhat smaller. The venation is shown by Saporta's drawings to be identical.

The distribution of *Ch. Lanzæanum* is consequently extended in Europe to the Middle Eocene of Monte Promina, the Upper Eocene of Aix, and possibly to the Aquitanian of Manosque. The fossil species appears, therefore, to have had a wide range like the existing one; a fact in accordance with its exceptional range and abundance in the English Eocenes.

The presence of *Chrysodium* in Europe so late as the Middle Tertiary period has thus been ascertained by numerous specimens, most of them of very recent date.

Saporta and Heer have also detected a resemblance in the Eocene species to *Gymnogramma Gardneri*, Lesquereux;[1] indeed, Saporta had suggested this affinity[2] to Lesquereux during the publication of his work. Lesquereux, however, informs me, after comparing the specimens which I forwarded to him, that, although a considerable correspondence exists, the venation in his species is much looser, and the midrib is of a different type. With reference to Lesquereux's determination of the American species as a *Gymnogramma*, Heer thinks it still doubtful, until fructification shall have been found, whether all the species belong to that genus (*Dictyogramma*, Fée.), or to *Chrysodium*.

Chrysodium Lanzæanum is locally abundant, ranging from the Lower Bagshot through the Bournemouth Beds, and is met with in the marine beds overlying them, and at Hordwell. It is exceedingly common in beds on both sides of Bournemouth Pier, and scarcely less so in the widely separated beds at Studland.

De-la-Harpe mentions a small fragment in Prestwitch's Collection, and to which he doubtfully attached the name *Acrostichum*, as having been obtained at Alum Bay; but its occurrence there has not since been confirmed. Usually only torn, twisted, and detached fragments are met with; and the specimen figured in Pl. I, from a bed of black clay under the Coastguard Station at Bournemouth, is the only one in which the pinnæ have been found attached. No traces of fructification have yet been detected. Carruthers, being present when the larger specimen was found, immediately recognised its affinity to *Chrysodium vulgare*. This alliance has also been admitted by Hooker and other English botanists who have seen it, so that the correctness of the determination, due in the first instance to Carruthers, is unquestionable.

The specimens figured, Pl. II, figs. 3, 3*a*, 4, are from Studland; Pl. II, figs. 1, 1*a*, 2, 2*a*, and Pl. I, are from Bournemouth. In the former the secondary veins are more closely set.

[1] 'Tertiary Flora of America,' p. 58, pl. 4, fig. 2.

[2] Op. cit., p. 58.

(B) *Polypodieæ.*

Gen.—PODOLOMA, *Ett.*

Filices herbaceæ, fronde simplici, integra; sporangia nervis imposita, in soros subrotundos sparsos indusio nullo obtectos collecta. Nervatio Phlebodii irregularis.

PODOLOMA POLYPODIOIDES, *Ett.* and *Gard.* Plate III, figs. 4, 5, 6, and 9.

P. fronde submembranacea, lanceolata vel lineari-lanceolata, integerrima, utrinque angustata; nervatione Phlebodii irregularis; nervo primario rhachidromo, recto, prominente, apicem versus sensim attenuato, nervis secundariis sub angulis 55—65° *orientibus brochidodromis; maculis medianis vix distinctis, inæqualibus; laqueis Phlebodii semiellipticis, inæqualibus; maculis lateralibus irregularibus minutis,* 1—3 *seriatis; appendices numerosos tenuissimos ramosos includentibus.*

Middle Bagshot, Bournemouth.

This genus and the next approach the *Dictyopterideæ* of the older floras and certain recent tropical species of *Polypodium* belonging to the sub-genus *Phymatodes*, namely, *P. lycopodioides*, *P. persicariæfolium*, *P. salicifolium*, *P. transparens*, and *P. hemionitideum*. The leaves may be distinguished from dicotyledons, notwithstanding their superficial resemblance, as, independently of the remains of spore-cases, they possess the peculiar venation of this section of *Polypodium*.

FIG. 12.—P. lycopodioides.

The frond represented in Pl. III, fig. 9, offers points of agreement in form, texture, and venation, with the barren frond of the recent *Polypodium lycopodioides*. The fossil presents the Phlebodium type of venation, modified by a less uniform shape and by the inequality of the meshes abutting on the midrib, which hardly differ from the rest. The Phlebodium loops are irregularly arranged and of unequal length and breadth. The two to three rows of marginal meshes, instead of being elliptical, are irregularly angular, and filled with numerous free and anastomosing venules (Pl. III, fig. 5). These differences are the bases of a new type, deviating essentially from the Phlebodium appendiculatum to which *P. lycopodioides* belongs, and is called Phlebodium irregulare. Figs. 4 and 9 are of natural size, and show the general form and average size of the pinnæ. Fig. 5, which is the base of a pinna enlarged, accurately shows the venation in detail, and, in three places, what appear to be sori in an early stage of development, around which the arrangement of meshes is peculiar.

Fig. 6 is another fragment, further enlarged, showing small spherical markings, which require further elucidation.

PODOLOMA AFFINE, *Ett.* and *Gard.* Plate III, figs. 7, 8.

P. fronde membranacea, lanceolata integerrima; nervatione Phlebodii irregularis; nervo primario rhachidromo, recto, prominente, apicem versus sensim attenuato; nervis secundariis sub angulis 30—45° *orientibus flexuosis brochidodromis, maculis medianis non distinctis, laqueis Phlebodii irregularibus, inæqualibus; maculis lateralibus inæqualibus,* 1—2 *seriatis, appendices numerosos tenuissimos ramosos includentibus.*

Middle Bagshot, Bournemouth.

This is of a more delicate and membranous texture than the preceding, a distinguishing character in itself. In addition the secondary veins diverge at a more acute angle, are slightly sinuous, of unequal length, and at different distances apart. The median meshes which characterise the Phlebodium venation, discernible in the preceding species, are not perceptible in this, but in the magnified figure (Pl. III, fig. 8) a number of very irregular meshes are seen abutting on the midrib and taking the place of these median meshes. The Phlebodium loops, as well as all the meshes, are very irregular and unequal in form and size. The dots, visible without a lens, are evidently the bases of attachment of sori.

These two forms of Polypodieæ are found massed together in layers in the highest freshwater beds, immediately underlying the marine beds. Dicotyledonous leaves seldom accompany them, but they are generally associated with torn fragments of aroids, rushes, and conifers, and occasionally with remains of other ferns, as *Osmunda, Pteris,* and *Chrysodium.* The venation is usually well preserved and distinct, but the pinnules are always detached and the fructification removed, as if by maceration. The separating layers are so thin and brittle, and the leaves so crowded together, that it is extremely difficult to secure good specimens. The recent *Polypodia* with which they have been compared have long creeping rhizomes, with simple and persistent fronds, not articulated; but the fact that in the fossils the pinnules are invariably detached and in layers suggests that they belonged to annual ferns with articulated pinnæ. Their geological position and the leaves associated with them suggest that they inhabited swampy districts near the sea-shore.

Saporta, in a letter full of valuable comments, points out the resemblance which *Podoloma* bears to the dicotyledonous *Myrsiniæ, Sapotaceæ,* and the genus *Bumelia.* The venation, however, seems to differ more from any of these than from that of some existing Ferns. The existence of sori, besides, seems placed beyond doubt. Heer also

pronounces a decided opinion that they belong to the division of *Polypodium* with reticulate venation, and does not think that they should be generically separated unless as *Polypodites*. Hooker, Carruthers, and others see no reason to create a new genus for their reception. The correctness of our determination of these as Ferns may, we think, be considered as beyond reasonable doubt.

No fossil *Polypodia* with reticulate venation resembling these had hitherto been described.

GLOSSOCHLAMYS, *Ett.*

Filices herbaceæ, fronde simplici, integra. Nervatio Drynariæ irregularis.

GLOSSOCHLAMYS TRANSMUTANS. *Ett.* and *Gard.* Plate III, fig. 3.

G. fronde submembranacea, petiolata, lanceolata, utrinque angustata, apice longe-acuminata, margine integerrima; nervatione Drynariæ irregularis, nervo primario rhachidromo, recto, prominente, apicem versus sensim attenuato; nervis secundariis prominentibus camptodromis adscendentibus, mediis sub angulis 40—50°, *reliquis sub angulis acutioribus orientibus; nervis tertiariis catadromis; latere externo angulo subrecto, latere interno plerumque angulis variis egredientibus; segmentis tertiariis vix distinctis, inæqualibus, irregularibus, polygonatis; maculis appendices plerumque liberos includentibus.*

Middle Bagshot, Bournemouth.

The texture of this frond was membranous. The apex is very elongated and narrow. The venation is somewhat like that met with in certain species of *Polypodium*, as, for example, *Phymatodes hemionitideum* and *P. transparens*, and in some species of *Aspidium*, as *A. trifoliatum*, *A. macrophyllum*, *A. pachyphyllum*. It deviates, however, in some essential particulars. The secondary veins are not sinuous, but run towards the apex of the frond in long curves, close to and sub-parallel with the margin. Their angles of departure are more acute at apex and base than in the middle of the frond, and in this respect the resemblance to dicotyledonous venation is great. The remaining characters of the venation are of the Drynaria irregularis type. In the catadromous loops of the ternary veins it approaches the above species of *Aspidium*. The species is founded upon peculiarities of venation, which consist in the ternary diverging from the outer side of the secondary veins at right angles, and from their inner side at varying acute and obtuse angles, and also in their relatively inconspicuous ternary segments, in proportion to the meshes and venules that are enclosed in them.

Saporta objects to the reference of this fossil to a Fern, as he considers the venation to be quite unlike that of any Fern, and to belong to a type common among dicotyledons. Heer also states that, in his opinion, "it is not a Fern, but a leaf of a Dicotyledon." It is found associated with Podoloma.

(c) *Pterideæ.*

PTERIS EOCÆNICA, *Ett.* and *Gard.* Plate IV, figs. 4—6.

P. fronde pinnata, pinnis rhachi angulo peracuto insertis, sessilibus valde elongatis, lanceolato-linearibus, acuminatis, basi obliquis, margine tenuissime serrulatis; nervatione Neuropteridis acrostichaceæ, nervo primario prominente, recto, apicem versus sensim attenuato; nervis secundariis sub angulis 40—50° *orientibus,* 1·5 *millim. inter se distantibus, bi- vel trifurcatis, rarissime simplicibus, ramis inter se parallelis, cum nervo primario angulum subrectum formantibus.*

Middle Bagshot, Bournemouth.

This species is characterised by its long, narrrow pinnæ, which quit the rachis at angles of about 25°. Towards the apex of the frond they are sometimes confluent, decurrent below on the rachis, as in Pl. IV, figs. 4 and 5, and apparently petiolated towards the base. The terminal pinna is the largest. The margins of the pinnæ are sinuous or alternately lobed, and very finely toothed. The midrib is prominent and elongated. The secondary veins are numerous and crowded, spring at acute angles, curve outwards to the margin, and terminate in the teeth, the majority of them being once, some twice forked, and a very few undivided. The venation is of the type of Neuropteris acrostichacea, which is not uncommon in recent and fossil species of *Pteris.*

P. eocænica resembles very closely a number of living species of *Pteris,* as *P. crenata, P. cretica,* &c. It also resembles the Aquitanian species, *P. pennæformis,* Heer,[1] but may be distinguished by the secondary veins, which are less crowded and more generally forked, and by the margin, which is lobed and toothed in a much more pronounced manner. It even more closely resembles *P. Parschlugiana,* Unger, and *P. Gaudini,* Heer, but differs from the former in the much more acute angle at which the pinnæ leave the rachis, whilst the latter, founded upon a single and very small fragment, has no specific character, and is possibly, as suggested by Heer himself,[2] a fragment of *P. pennæformis.* The American Eocene[3] species *P. subsimplex* and *P. erosa,* while possessing the same

[1] 'Flor. Tert. Helv.' vol. i, p. 38, pl. xii, fig. 1.

[2] 'Flor. Ter. Helv.,' vol. i, p. 39.

[3] Lesq., 'Tert. flora of America,' 1878, pl. iv, pp. 52, 53.

venation, have much broader pinnæ, and *P. pseudopennæformis* has more closely and obliquely set secondary veins. *Blechnum Braunii*, Ett., from Monte Promina, has similar venation and finely toothed margin; and Dr. Debey informs me that he has Ferns from Aix-la-Chapelle with a nearly related venation. Heer believes it bears a resemblance to *Pecopteris Hookeri*, from Bovey Tracey. *Osmunda eocænica*, Saporta,[1] from Gelinden, strikingly resembles it, but seems to have been a larger Fern, and is considered distinct by Saporta.

Pteris eocænica is abundant at Bournemouth in the "fern-beds," where it is associated with the Polypodieæ. It becomes rarer westward, having but once been met with west of the pier, and then only in the highest and remanié beds near the top of the cliff, immediately under the flagstaff. The specimen from this locality (Pl. IV, fig. 5) is dwarfed and attenuated. The abundance of this Fern in the newest and most easterly beds of the Bournemouth freshwater series, where it is associated with plants which required much moisture, its rarity in the slightly older beds to the west, which have a less swampy character, its dwarfed and starved appearance in the uppermost beds west of the pier, and its complete absence from all the lower beds in which, with few exceptions, the dicotyledons have been obtained, point to its habitat having been, by preference, of a swampy and marshy character, and near the sea-level. Saporta informs me that at Manosque the closely allied *P. pennæformis* is, like this, found associated with *Chrysodium Lanzæanum* and *Osmunda lignitum*.

I am indebted to Mr. A. Baldry, of Bournemouth, for the specimen, fig. 5, Pl. IV, which we at first thought to be distinct, as the pinnæ are smaller and narrower, and the secondary veins more widely separated and less diverging. Fig. 6 (Pl. IV) represents a terminal pinna, natural size; fig. 4, the lower part of a frond; fig. 6 *a*. enlarged venation.

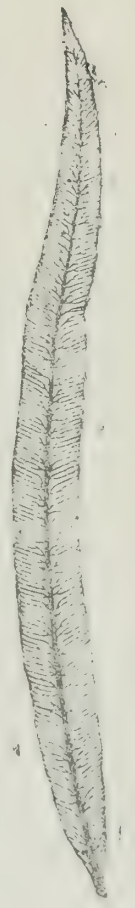


Fig. 13.—Pteris crenata.

Although species of *Acrostichum*, *Angiopteris*, *Gymnogramma*, &c., possess similar venation, the characters furnished by this form so closely correspond to what is met with in the recent species of *Pteris*, that its reference to this genus cannot be doubted.

Pteris Bournensis, *Ett.* and *Gard.* Plate IV, fig. 7.

P. fronde bipinnata, pinnulis superioribus angulo acuto, reliquis angulo subrecto rhachi adnatis, basi lata sessilibus, lanceolatis, acuminatis, margine integerrima vel leviter undulata; nervatione Alethopteridis genuinæ; nervo primario debili, recto, infra apicem valde attenuato, nervis secundariis sub angulis acutis orientibus.

[1] 'Flore Heersienne de Gelinden,' Saporta and Marion, 1878, pl. i, fig. 1.

Middle Bagshot, Bournemouth.

The specimen figured is apparently of delicate texture, and may be either the apex of a barren frond or the fragment of a pinna. The pinnules are lanceolate and gradually attenuated towards the apex, entire or slightly undulate, broadest at the base, and confluent. The uppermost pinnules are attached at acute, and the others at about right angles. The midrib is thin and tapering; the secondary veins, ten or twelve in number on each side, spring at angles of 50°—60°, and are mostly forked. The venation is of the true Alethopteris type. The apparently thin texture may be due to the long maceration to which the leaf has evidently been subjected.

The specimen so closely resembles the figures of *P. Œningensis*, Unger,[1] that, judging from them alone, it might be placed with it. That species, however, is of a more coriaceous texture, and appears only towards the second part of the Miocene. In connection with it Saporta has kindly communicated that he considers *P. Œningensis*, which appeared late in the Miocene, to be the forerunner of *P. aquilina*, and that the Miocene form was preceded by *P. urophylla*, and this by *P. Aquensis* and *P. caudigera* of the Aix beds. The type of *P. aquilina* is probably very ancient, and may reasonably be looked for in formations as old as the Lower Eocene. Debey thinks he has a similar type from Aix-la-Chapelle.

This Fern, which differs essentially from the *P. eocænica*, is known from a single fragment only, met with among dicotyledons in a leaf-bed on the coast near Poole Harbour. Fig. 7 is drawn the natural size; 7 *a* shows a portion magnified.

The determination of this as *Pteris* is not absolutely certain in the absence of fructification, as the venation is common to many Ferns.

(D) *Aspleniæ*.

ASPLENITES PRÆ-ALLOSUROIDES. *Ett.* and *Gard.* Plate III, figs. 1, 2.

A. fronde membranacea, tripinnata, pinnis bipinnatis patentibus, pinnulis stipitatis, ellipticis, subobtusis, tenuissime crenulatis, soris oblongis, biserialibus; nervatione Craspedopteris veræ, nervo primario tenui, infra apice evanescente, nervis secundariis tenuissimis, simplicibus.

Middle Bagshot, Bournemouth.

The specimen appears to be the remains of a fertile frond, and recalls a somewhat

[1] Heer, 'Flor. Tert. der Schweiz,' vol. i, p. 39, pl. xii, fig. 5.

similar form, *Asplenites allosuroides*, described by Unger,[1] from Eocene beds with *Cerithium margaritaceum*. The frond seems tripinnate, the pinnæ spreading, and the very small pinnules shortly stipitate, elliptical, and sub-obtuse at both ends. The margin has three to five teeth. The secondary veins quit the midrib at angles of 40°—50°, are simple, and terminate in the teeth, being therefore of the Craspedopteris vera type. The enlargement (Pl. III, fig. 1) is after a drawing by Carruthers, who kindly assisted in the elucidation of the specimen, which is very obscure indeed. The pinnules were of great substance, and the leaf has therefore carbonised and broken away. The rachis is zigzag.

Stur has kindly remarked upon the strong resemblance borne to our species by *A. allosuroides*. Unfortunately this was also determined upon a specimen in which the details were badly preserved, inasmuch as the carbonised leaf-substance from the same cause has almost entirely dropped out, and only the impression remains. It differs from *A. præ-allosuroides* in size, it being nearly double, and in the more rotundately elliptical pinnules, and as far as can be seen in their less symmetrical arrangement on the frond.

It, as well as *A. allosuroides*, closely resembles *Pteris heterophylla*, Linn., which has coriaceous pinnules of exactly the same form, but larger. In this respect the Sotzka species connects the two. The recent *Pteris scaberula* has the pinnules as finely divided as the Bournemouth form.

It does not bear any close resemblance to existing species of *Pellæa* or *Asplenium*; but *Gymnogramma leptophylla* slightly resembles it. Its determination is exceedingly doubtful. Heer is of opinion that it is the fertile frond of a species of *Thyrsopteris*.[2] It may, should better specimens be found, be necessary to unite our species to Unger's; and this seems the more probable as a great number of Sotzka plants are associated with it at Bournemouth.

The specimen, which is unique, was found some years ago at Bournemouth, under the Coast-Guard Station, by Mr. W. S. Mitchell and Henry Keeping, and is now in the British Museum.

(E) *Aspidieæ*.

Gen.—MENIPHYLLUM, *Ett.*

Filices herbaceæ, fronde pinnata, nervatio Drynariæ compositæ.

This genus is allied to *Meniscium* in its marginal secondary and short ternary veins,

[1] 'Fossil Flora of Sotzka,' l. c., p. 25, pl. i, fig. 1.

[2] 'Flor. Foss. Arctica,' iv, pl. x; Jurassic flora of Siberia.

but it is distinguished from this and from *Drynaria* by the anastomosing of the ternary veins and presence of free venules in the meshes. In the combination of marginal and netted venation, it presents a special type of the Drynaria group, which has never been observed in recent Ferns.

Fig. 14.—Meniscium longifolium.

MENIPHYLLUM ELEGANS, *Ett.* and *Gard.* Pl. III, figs. 10—14.

M. pinnis subcoriaceis, stipitatis, lanceolatis, apicem versus acuminatis, basi acuta inæqualibus vel obliquis, margine integerrimis; nervo primario valido prominente, sæpe arcuato vel flexuoso, nervis secundariis sub angulis 75—90° *orientibus, numerosis, approximatis, flexuosis; nervis tertiariis angulis acutis, rarius obtusis e nervis secundariis egredientibus, abbreviatis, flexuosis; maculis oblongo-ellipticis, appendices liberos includentibus.*

Middle Bagshot, Bournemouth.

At first sight these remains appear to belong to *Meniscium*, but although the shape of the pinnæ and the arrangement of the secondary veins point to this affinity, the venation itself is opposed to it; for, whilst *Meniscium* has the Goniopteris, this has the Drynaria type. Pl. III, fig. 13, shows the venation magnified. The fronds were pinnate and probably coriaceous in texture. The pinnæ are shortly stipitate, the stalk passing into the mid-rib, which is curved or sinuous. The secondary veins are given off at rather obtuse, often almost right angles, and are numerous and closely set, thicker and less sinuous, and usually alternate with more slender and sinuous secondary veins. All extend to the margin, where they are either forked or remain undivided. The ternary veins form various acute and more rarely obtuse angles, are mostly very short and sinuous and anastomose more frequently with the neighbouring secondary veins than together. The meshes are of irregular oblong and elliptical shape, and contain branched free venules.

The pinnæ represented (Pl. III, figs. 10, 11, 12) were found at Bournemouth in the beds near the top of the cliff east of the Pier, associated with aroïds, palms, and conifers. It is sometimes found with *Podoloma*. Fig. 14 is from a solitary specimen found under Branksome Watch Tower, towards Poole Harbour, associated with small oak- and willow-like leaves. The pinna seems to have been slightly shrivelled at the margin before it was imbedded, and hence the lateral marginal vein is hardly discernible.

This determination should be received at present with some hesitation, since we know of no existing Fern possessing crowded secondary veins and free venules, and the venation on the other hand resembles that of certain dicotyledons.[1]

PHEGOPTERIS PRÆ-CUSPIDATA, *Ett.* and *Gard.* Plate IV, figs. 8, 9.

Ph. fronde pinnata, pinnis lanceolato-linearibus, elongatis, crenato-serratis; nervatione Goniopteridis Meniscii, nervo primario prominente, recto; nervis secundariis sub angulis 60—75° *orientibus, numerosis, tenuibus, simplicibus, flexuosis; nervis tertiariis utrinque* 4—6 *e nervis secundariis angulis acutioribus egredientibus, anastomosantibus, catadromis; radiis interruptis vel obliteratis.*

Middle Bagshot, Bournemouth.

The pinnæ are linear-lanceolate, obtusely serrate, with the venation of *Goniopteris*, in which all the ternary veins anastomose. It is referred to the Goniopteris Meniscii type, because the rays are interrupted and not continuous. It is probably a *Phegopteris*, and, indeed, differs only from *P. cuspidata*, Mett., in the following unimportant particulars: the marginal teeth are rather more obtuse or crenate; the midrib is prominent yet less thick; the secondary veins are sinuous instead of only curved upwards near the margin, less close, and at more acute angles; the lower ternary veins have a distinctly catadromous origin; the ramifications are usually very short, interrupted or abortive instead of always present. Its similarity to *Gymnogramma villosa* of Brazil is also striking.

There are also certain resemblances between this and the Miocene forms *Phegopteris Helvetica* (*Lastræa*), Heer,[2] *Ph. polypodioides*,[3] and *Ph. Stiriaca*,[4] also abundant at Bovey Tracey.

Heer would unite it with *Ph. Bunburyi* next described, considering it to be a fertile rond of that species; but although the venation in the only Bournemouth specimen is so indistinct that I am not inclined to attach too much importance to it, yet it hardly seems to justify the union. Pending the discovery of better specimens, I think they must be considered distinct.

The portion of a fertile frond figured is unique, and was obtained at Bournemouth, together with a magnificent series of dicotyledonous leaves of large size and palms, from one of the lower beds under the Coast-Guard Station, and therefore may be presumed from its surroundings to have had a shady forest habitat, and to have required a high temperature.

[1] Saporta has pointed out that the venation is not very dissimilar to that of the dicotyledonous genus *Andromeda*, sub-genus *Leucothöe*.

[2] 'Flor. tert. der Schweitz.,' pl. vi, fig. 2, pl. cxliii, figs. 2—5.

[3] Ett., 'Monte Promina,' pl. ii, figs. 1—4; Heer, loc. cit., pl. cxliv, figs. 1—3.

[4] Ung., 'Chlor. Prol.,' pl. xxxvi, Heer, loc. cit., pls. vii, viiii.

PHEGOPTERIS BUNBURII, *Heer*. Plates V and X.

LASTRÆA BUNBURII, *Heer*. Flora of Bovey Tracey, p. 28, pl. xii, fig. 1 *b*.

FIG. 15.—Phegopteris cuspidata.

Ph. fronde pinnata, pinnis breve petiolatis, lanceolatis, basi acutis, apicem versus angustatis, serratis, margine arguta; nervatione Goniopteridis Aspidii; nervo primario prominente, recto; nervis secundariis sub angulis 50—60° *orientibus, tenuibus, flexuosis, pinnatis; nervis tertiariis utrinque* 2—4, *sub angulis acutis egredientibus, flexuosis curvatisque; radiis perviis.*

Middle Bagshot, Bournemouth.

To Heer we are indebted for pointing out the identity of the Bournemouth form with that of Bovey Tracey.

In this Fern the fronds were pinnate, the pinnæ usually rounded at the base and probably acuminate at the apex, and with lightly toothed margin. The pinnæ are wide apart towards the base of the frond and confluent towards the apex. The venation is of the type of Goniopteris Aspidii. All the ternary veins anastomose among themselves, and the venules proceeding from them are excurrent. The midrib is not thick, yet several times more prominent than the secondary veins, which are themselves slender, sinuous, and shortly forked at the extremities. The ternary veins are fewer, only two on each side, they part at a less acute angle than the secondary ones, and form a sharp curve, which unites them with the next above of the same order. It rather resembles some existing species of *Asplenium*, sub-genus *Diplazium*, chiefly *A. expansum* and *A. Ottonis* of Tropical America. It agrees closely in its characters with *P. Œningensis*, Heer,[1] which differs from ours only in the stipitate pinnæ, rather closer secondary veins, and in the possession of three or four ternary veins on each side of the secondary. Stur sees a resemblance rather to *Osmunda*, as *O. Claytoniana* and *O. cinnamomea*.

The specimens were found in the fourth bed of the series, under the Coast-Guard Station at Bournemouth; and no fragments have elsewhere been met with, except at Bovey Tracey, where it is also extremely rare. It appears to have been a slender, graceful plant, growing under the shade of the trees with whose leaves it is found associated. That figured in Plate V is evidently a young, perhaps sterile plant. In Plate X is shown a perfect pinna.

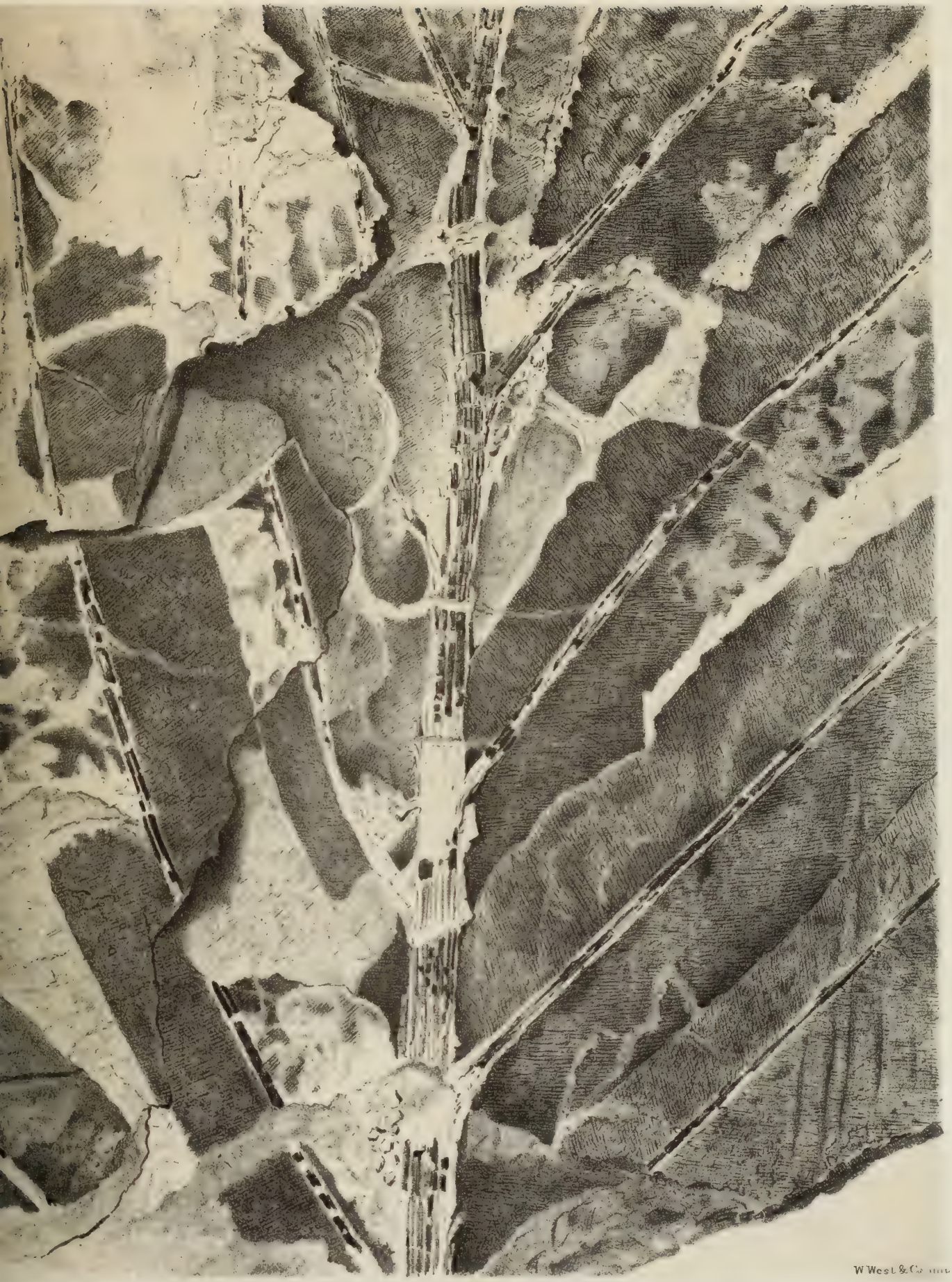
[1] Loc. cit. p. 32, Pl. VI, fig. 3.

PLATE I.

From the Middle Bagshot Beds, Bournemouth.

Chrysodium Lanzæanum (Visiani).

Fig. 1. A unique specimen, with pinnæ attached. (Gardner Collection.)



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EOCENE FERNS

PLATE II.

From the Lower Bagshot Beds of Studland, and the Middle Bagshot Bed of Bournemouth.

Chrysodium Lanzœanum (Visiani).

Fig. 1. Fragment of a pinna, from Bournemouth.
1 *a*. Portion of the venation, magnified.
2. Terminal pinna, from Bournemouth.
2 *a*. Portion of the venation, magnified.
3. Apex of a pinna, with unusually close venation, from Studland.
3 *a*. Part of the same, magnified.
4. Fragment of a pinna, from Studland, with few anastomosing ternary veins.

(All the above from the Gardner Collection.)

Filices incertæ sedis.

5. Adiantum? (From Mr. Pender's Collection.)
6. Leaf with Cyclopteris venation. (British Museum.)

W.West & Co. imp.

EOCENE FERNS

PLATE III.

From the Middle Bagshot Beds, Bournemouth.

Asplenites præ-allosuroides, Ett. and Gard.

Fig. 1. Part of frond, magnified. (British Museum.)
2. The specimen, natural size. „

Glossochlamys transmutans, Ett. and Gard

3. Frond, natural size. (Gardner Collection.)

Podoloma polypodioides, Ett. and Gard.

4. A pinna, of average size.
9. A shorter pinna.
5. The base of a pinna, magnified, showing sori.
6. Fragment, magnified, probably of a different species, showing impressions of sori. (Gardner Collection.)

Podoloma affine, Ett. and Gard.

7. Fragment of pinna.
8. The same enlarged, showing bases of attachment of the sori. (Gardner Collection.)

Meniphyllum elegans, Ett. and Gard.

10. A small pinna, nearly perfect.
11. The base of a larger pinna.
12. A fragment of a still larger specimen.
13. A portion of the venation, magnified.
14. Slightly shrivelled pinna. (Gardner Collection.)

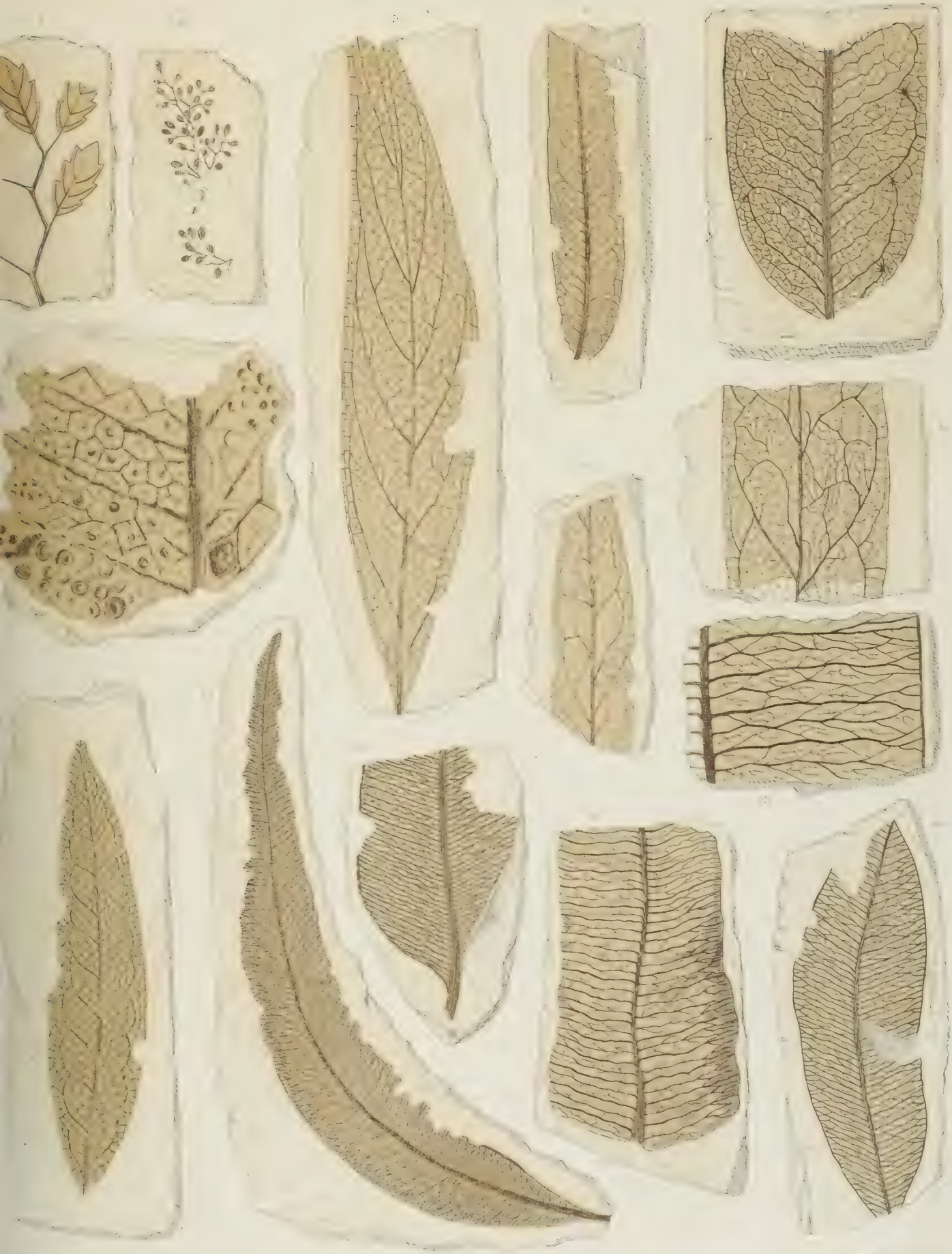

PLATE IV.

From the Middle Bagshot Beds, Bournemouth.

Osmunda lignitum (Giebel).

Fig. 1. Pinna, natural size.
1 *a*. The same, magnified.
2. A small pinna, natural size.
3. A pinna, natural size. (Gardner Collection.)

Pteris eocænica, Ett. and Gard.

4. Portion of frond, with pinna attached to the rachis, natural size. (Gardner Collection.)
5. Terminal portion of a stunted frond, natural size. (From the Collection of Mr. A. Baldry.)
6. Terminal pinna, average size.
6 *a*. Part of the same, magnified. (Gardner Collection.)

Pteris Bournensis, Ett. and Gard.

7. Pinna with pinnules, natural size.
7 *a*. Part of the same, magnified. (Gardner Collection.)

Phegopteris præ-cuspidata, Ett. and Gard.

8. A unique pinna, natural size.
9. Portion of the reverse of the same specimen.
9 *a*. Part of the same, magnified. (Gardner Collection.)

EOCENE FERNS

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PLATE V.

From the Missouri Botanical Park, Witnessworth

Phegopteris Barbarii, Hunt.

Fig. 1. A young plant, natural size. (*Gardiner Collection.*)

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SECOND SUPPLEMENT

TO THE

MONOGRAPH OF THE CRAG MOLLUSCA,

WITH

DESCRIPTIONS OF SHELLS

FROM THE

UPPER TERTIARIES OF THE EAST OF ENGLAND.

BY

SEARLES V. WOOD, F.G.S.

VOL. IV.

UNIVALVES AND BIVALVES.

LONDON:

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General Title-page; Pages i, ii; 1—58; Plates I—VI.

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PREFACE.

When I had completed my first Supplement to the "Crag Mollusca" in 1872–4, I did not contemplate ever attempting any further addition, as even if I had desired to make any, my advanced years rendered it improbable that I could accomplish such a thing. The discovery, however, of some shells at Boyton, one of them (*Fusus Waelii*) apparently identical with a shell from older beds in Belgium and Germany, and two others (*Murex Reedii*, and *M. pseudo-Nystii*) presenting an approach to certain Murices of the same older beds, were of such interest as to render their representation by figure and description desirable, for if, as is probable, they lived in the Coralline Crag sea, they furnish evidence of a nearer connection of that sea with the Miocene than modern opinion has been inclined to grant.

I was thus induced to enter upon a second Supplement, which I at first thought might be confined to a single plate, but when this had been engraved I reflected that as so many species had been introduced into lists of Crag shells, which I had not introduced into my first Supplement from a feeling that the authority for them was too scant or doubtful to justify it, or, in some instances, from a feeling that the identity was erroneous, it was incumbent on me to present to geologists by figured representations the evidence upon which these introductions were based. This, therefore, I have endeavoured to do, and by it have, perhaps, exposed myself to the objection that the plates have been extended to but little purpose, as many of the so-called new species are either very doubtful in themselves, or are merely derivatives from destroyed beds; though most of these beds probably belong either to the Coralline, or to some still older part of the Crag; *i.e.* to the oldest Pliocene, now present in Belgium. To such objections my answer would be that I have long felt that the introduction of so many new species into Crag lists, either from the unsatisfactory evidence of a single specimen, or from the (in my view) improper identification made, or from the presence of mere derivatives, must produce among geologists, especially those abroad, very erroneous conceptions of the Crag Fauna; and that it was to the advantage of science that these evidences should be placed in an appreciable form before the scientific world.

I fear that most of the additions thus made of late years to the Crag Fauna, coupled with the antagonism between the views of Dr. Jeffreys, concerning the identification of many Crag shells with recent species (as expressed by the list which accompanies the paper of Prof. Prestwich, in the twenty-seventh Volume of the 'Journal of Geological Society') and those of myself, will render the subject of the Crag Mollusca, for some time to come, a subject of more perplexity than interest to students of the upper tertiaries.

I have now by inquiry in every quarter which afforded the slightest chance of result exhausted all possible additions to the Molluscan Fauna of the Crag up to the present time, doubtful or otherwise, and dealt with them in the present Supplement.

Dr. Lycett has (after a lapse of more than twenty years) written to me that the attribution of an analysis of the *Myadæ* to Prof. Morris made in the footnote to p. 265 of my second volume of the "Crag Mollusca" was an error, and that the analysis was entirely his own. I take this opportunity, therefore, of acknowledging the error, and of expressing my regret for it.

S. V. WOOD.

November, 1878.

SECOND SUPPLEMENT

TO THE

CRAG MOLLUSCA.

BUCCINUM NUDUM, *S. Wood.* 2nd Sup., Tab. I, fig. 1 *a, b.*

Spec. Char. B. Testâ tenui, elongato-ovatâ, turritâ, lævigatâ, apice obtusâ, depressâ; anfractibus septenis, convexiusculis; suturâ impressâ; aperturâ ovatâ; labro tenui acuto, columellâ regulariter concavâ.

Axis $2\frac{1}{4}$ inches.

Locality. Cor. Crag, Sutton.

The shell here represented is from the collection of Mr. Canham, who tells me he obtained it from the lower part of the Cor. Crag at Sutton. The shell is very thin and fragile and has lost some small portion of its exterior and a small part of the shell, but it has retained its natural form by the somewhat slight consolidation of the material within. It resembles a shell I figured in my Suppl., Addendum Plate, fig. 11, under the name of *Buc. Tomlinei*, but that is not quite so elongated as the present one, and it is ornamented with large and distinct spiral striæ; while our present shell, where the outer coat has been preserved, appears to have been perfectly smooth and very thin. I have a cast of this shell in one of the so-called "box stones" of the Red Crag. It belongs apparently to a group of shells of which *Buc. Dalei* may be considered as the type; but it departs as much or more from that species as does the other Cor. Crag shell *pseudo-Dalei*. Both, however, are obnoxious to the same objection that they are founded on solitary specimens. To this objection the extreme rarity in the Cor. Crag of the normal form *Dalei* is to some extent an answer.

At fig. 5 *a, b,* tab. i, of the same plate is represented a specimen which I have referred (with doubt) as a deformity to *Buc. undatum;* it somewhat resembles a shell I figured in Sup. to Crag Moll., tab. ii, fig. 5, and considered as a deformed specimen or variety of that species, and I am inclined to think our present shell is in a similar condition. It was sent to me by Dr. Reed, and is said to have come from the Red Crag of Butley, the locality from which I obtained my specimen. The volutions are somewhat angulated at

the base, and slightly so at the shoulder, where there are traces of undulated ridges like those of *undatum*.

I have also figured another shell from the Cor. Crag belonging to Dr. Reed which, I think, is a deformed specimen of *Buccinum Dalei* (2nd Sup., tab. i, fig. 2); the thickened margin was formed, I imagine, when its growth was arrested, and the ridge upon the columella is, I think, the result of disease, and therefore only a malformation.

BUCCINUM DECLIVE, *S. Wood.* 2nd Sup., Tab. II, fig. 10 *a*, *b*.

Locality. Cor. Crag? Boyton.

This is another specimen out of the rich cabinet of Dr. Reed, who gives it from that somewhat doubtful locality of Boyton. This specimen may be described as ovato-fusiformi, spirâ elevatâ, apice obtusâ, spiraliter striatâ, anfractibus 5—6 convexis, suturis depressis, valdè distinctis, obsoletè costatâ; aperturâ ovatâ, labro simplici acutâ; canali breve. It is, I believe, distinct from any of the varieties of the variable shell *B. undatum*, the volutions are more convex, with a much deeper suture, and it has a more obtuse or mammillated apex.

The shell has been a good deal rubbed. The striæ, although somewhat obliterated, are visible in places, and the longitudinal ridges are also visible, but not very regular or distinct. These do not appear to be at all "undulated" as if the outer lip had been sinuated, and as this character seems to indicate that the shell is distinct from *undatum*, I have assigned to it the above name, but it must be regarded as a doubtful species.

NASSA PRISMATICA, *Brocchi.* 2nd Sup., Tab. I, fig. 6.

BUCCINUM PRYSMATICUM, *Broc.* Conch. Foss. Subap., p. 337, t. v, fig. 7, 1814.

Spec. Char. "*Testâ ovato-oblongâ, longitudinaliter costatâ, striis transversis crebris, elevatis, labro columellari, supernè uniplicato, basi reflexâ, emarginatâ*" (Brocchi).

Axis 1 inch.

Localities. Cor. Crag, Sutton.

Fossil in Piacentino, Italy.

The present specimen is from the cabinet of the Rev. Mr. Canham, and from the lower part of the Coralline Crag. The shell represented under this name in the Crag Moll. vol. i, p. 32, tab. iii, fig. 6, is, I now believe, a distinct species, and I have resumed the name of *Nassa microstoma* for it as next described.

Our present specimen is not quite so large as the one figured by Brocchi, which is a full-grown shell, whereas the one now represented has not attained to maturity, and has the outer lip sharp without denticulation on the inside of it.

NASSA MICROSTOMA, *S. Wood.* 2nd Sup., Tab. I, fig. 4 *a, b.*

NASSA MICROSTOMA, *S. Wood.* Catal. Mag. Nat. Hist., 1842.
— PRISMATICA, *S. Wood.* Crag Moll., vol. i, p. 32, t. iii, fig. 6, 1848.
— ELEGANS, *Dujard.* Tr. Geol. Soc. Fr., p. 298, pl. xx, figs. 3—10, 1837.

Spec. Char. Testâ turritâ, spirâ elevatâ, costatâ, costis 20—24, *spiraliter striatâ; anfractibus* 7—8, *convexis, suturis profundis, aperturâ rotundato-ovatâ; labro incrassato, intùs denticulato; labio supernè uniplicato.*

Axis $\frac{9}{16}$ of an inch.

Locality. Cor. Crag? Boyton.
Fossil in Touraine, France.

The specimen represented in the above figure is from the cabinet of Mr. Robert Bell, and he tells me that it came from Boyton. Doubts occur as to whether shells from this locality, not previously known in the Crag, belong to the Red or to the Coralline Crag,[1] but I am inclined to refer our present specimen to the older formation, both from the colour and appearance of the shell and from its apparent connections.

I now consider this species as specifically distinct from *prismatica*, and probably the same as the shell figured in Crag Mol., vol. i, Pl. III, fig. 6, and which in my synoptical list is inserted as *Nassa prismatica* var. *limata*. I refer it to *N. elegans*, Dujardin, an abundant Touraine shell which is much less than *prismatica*, has a greater number of costæ, and a smaller opening comparatively; as it is quite distinct from the well-established Red Crag species called *N. elegans* by the late Rev. G. R. Leathes in 1824, while Dujardin's name of *elegans* bears a date of 1837, it is necessary to suppress the latter to avoid confusion, and I have therefore assigned to it the name *microstoma* which I used first in my catalogue of 1842 referred to.

[1] I have not been able to see the Boyton excavation open, but I am informed that a thin layer of Red Crag is found there reposing upon a small thickness of Coralline, and the whole being inundated with water the two are shovelled out together and washed for the phosphatic nodules, so that the specimens from each bed are intermingled beyond possibility of distinction other than what may be drawn from the appearance of the specimen or the character of the species.

NASSA CONSOCIATA, *S. Wood.* 2nd Sup., Tab. IV, fig. 13 *a*, *b*; Crag Moll., vol. i, p. 31, Tab. III, fig. 7.

Axis $\frac{3}{4}$ths of an inch.

Locality. Red Crag, Waldringfield.

The specimen figured as above referred to is said by Mr. Canham to be from Waldringfield, and is in the collection made by him and now placed in the Ipswich Museum. That locality has yielded so many derivatives that I think the present shell may have been introduced from the destruction of material belonging to the Coralline Crag period. It is larger than any specimen I have from this latter formation, but this constitutes the only difference that I can discover.

Tab. IV, fig. 15, represents a small specimen of *Nassa* from the Red Crag of Butley, sent to me by Mr. Robert Bell with the MS. name of *N. tumida*, as he considers it a distinct species. This I have had figured, as it presents some differences from *N. incrassata* (the shell to which I believe it approaches nearest) in being more ovate and possessing more numerous costæ, and in being smaller; but as I do not think that these suffice to distinguish the shell specifically from *incrassata*, I have here called it var. *tumida* of that species. In the same Plate, fig. 12, is represented a small specimen from the Red Crag of Sutton, which I think is only a dwarf individual of *Nassa granulata*, here called var. *nana;* it much resembles *N. granifera*, but in that shell the costæ stand further apart with a plain space between them. In our present shell the costæ meet at the bases.

NASSA ANGULATA? *Brocchi.* 2nd Sup., Tab. IV, fig. .

BUCCINUM ANGULATUM, *Broc.* Conch. Foss. Subap., p. 654, tab. xv, fig. 18, 1814.

Locality. Boyton.

This is another form of the genus *Nassa* for which I have had great difficulty in making a reference, and have given to it the above one provisionally, having seen but the single specimen now figured, and this comes from a locality of doubtful age. It is from Mr. Robert Bell.

COLUMBELLA? (ASTYRIS) SULCULATA, *S. Wood.* 2nd Sup., Tab. I, fig. 3.

Spec. Char. C. Testâ turritâ, elongatâ, spirâ elevatâ, apice obtusâ, acuto? anfractibus convexiusculis, transversim late sulcatis; aperturâ quadrato-ovatâ; labro intùs denticulato; basi truncatâ, canali breve.

Axis $\frac{3}{4}$ths of an inch.

Locality. Red Crag, Sutton, Shottisham.

The specimen figured is from the cabinet of Dr. Reed, and to this the name of *Lachesis magna* was attached by Mr. A. Bell, but it appears to me to approach so near to *Columbella sulcata*, J. Sow., from Walton Naze, see Crag Moll., vol. i, p. 23, tab. ii, fig. 2, that I have given to it the same generic name of that aberrant section of *Columbella*.

Our present shell may be described as having an elevated spire, volutions slightly convex, ornamented with five or six rather broad and flattened striæ, separated by a fine and narrow line, with a deep and distinct suture; the aperture is ovately quadrangular, but not so much so as that of *C. sulcata;* the columella somewhat concave, and the canal short; the apex is not quite perfect.

Since the figure was engraved Mr. Robert Bell has presented me with a specimen of this species, a trifle larger than the one figured, and to this he has given the generic name of *Pisania*, but I see nothing in the specimen to require (according to my view) a new generic position.

I have here also given the representation of a shell in my own cabinet (2nd Sup., tab. iii, fig. 11), which I think is a distorted, abraded, and immature specimen of *Columbella sulcata*. It is ornamented with the same kind of spiral striæ, the last whorl (only) inflated, and the volutions are made more convex by decortication.

Lachesis Anglica, Sup., Crag Moll., Addendum Plate, fig. 7, probably belongs to the same section of *Columbella*. I do not know what especial character is given to the shell for the generic name of *Lachesis*.

PURPURA LAPILLUS. 2nd Sup., Tab. I, fig. 13.

The shell shown in the above figure represents a specimen that has been sent to me with the name of "Buccinum?" but I believe it to be simply a distortion of *Purpura lapillus*, and as it comes from Bramerton, whence I had previously received many specimens of other shells greatly distorted, I am strengthened in this view, and the shell may be classed with other distorted specimens figured in the Crag Moll.; see tab. iv, fig. 6, and tab. xix, fig. 12. The full-grown individuals of this species, or at least nearly all of them, have the outer lip sharp and simple, but in the young state the specimens are sometimes regularly and strongly dentated on the inside of the outer lip. I have other specimens of the same size, and less than the one figured, which have a few and strongly marked denticles on the right side of the aperture, but in general they are absent. The present specimen has been much rubbed and abraded, indicating the shallowness of the water in which it had lived. What should cause this peculiar dentation to the aperture in some of the young shells and not in others I am unable to explain. This character of dentation

is an accompaniment of the full-grown shell in most species rather than of the young, and I have had the specimen figured lest by any chance it should have been regarded as some new species and added to the number of such in lists of crag shells for which I can find no warrant.

Captain Brown has figured a specimen of this species with a dentated outer lip ('Illustr. Conch. Grt. Britain,' Pl. xlix, fig. 6), which he has called *Purpura Anglicanæ*, referring to 'Lister's Conch.,' Pl. 965, fig. 18. "Lister does not say from whence he obtained this singular variety" (Brown).

TROPHON (SIPHO) ISLANDICUS, *Chemnitz*. 2nd Sup., Tab. II, figs. 3 *a*, 3 *b* recent.

FUSUS ISLANDICUS, *Forb. and Hanl.* Brit. Moll., vol. iii, p. 416, pl. ciii, fig. 3, 1853.

Locality. Red Crag, Sutton.

The shell figured as above represents a specimen which I found many years ago and regarded as a var. of *Trophon gracilis*, figured and described in Crag Moll., vol. i, p. 46, tab. vi; but which I here give as a true representation of the recent British shell called *Islandicus* (fig. 3 *a*); and by the side of it have had engraved the figure of a recent specimen of that species for comparison,(fig. 3 *b*) because it has been said not to be a crag species. This shell is rather more elongated than *gracilis*, and deserves the name of *angustius*, originally given to it long before the time of Linné or of Gmelin, and which I adopted in my original catalogue published in the Annals of Nat. Hist. in 1842, p. 541. That name, however, being anterior to the time of our starting point, the 12th edit. of Linné, I give the shell under the usually received name of *Islandicus*.

TROPHON (SIPHO) TORTUOSUS, *L. Reeve*. 2nd Sup., Tab. II, fig. 2 *a*, *b*.

TROPHON GRACILE, var. *S. Wood*. Crag Moll., vol. i, p. 46, tab. vi, fig. 10 *b*, 1848.

Dr. Reed has lately sent me several specimens both from the Coralline and Red Crags that belong to a group of shells of which *Fusus Islandicus* may be considered as the type. Among those from the Red is one (fig. 2*a*) supplied by Mr. A. Bell and marked by the latter as *Fusus tortuosus* of L. Reeve, figured and described in Sir Edward Belcher's 'Last of the Arctic Voyages,' vol. ii, p. 394, Pl. xxxii, fig. 5 *a*, *b*.

The shell figured in the Crag Moll., tab. vi, fig. 10 *b*, is referred by Mr. A. Bell to the same species, and I am now disposed to think that Mr. Bell's references of this shell to Lovell Reeve's species is correct, if the differences be sufficient to constitute a specific

removal. Mr. Bell also says that fig. 10 *a, c*, of the same plate may be referred to *Fusus Olavii*, Beck, and considered a distinct species.

The principal character, indeed I believe the only one, by which *tortuosus* can be distinguished from either *gracilis* or *propinquus* is the greater convexity of the volutions; the form of the canal being similar in each with the volutions covered by regularly broad-spiral striæ. I have here had represented as above (fig. 2 *a*) the specimen from Dr. Reed, and which, in outward form, varies from the figure in the Crag Moll. as also from that given as mentioned by Lovell Reeve. I think it may be considered only as a variety; it is said to have come from Waldringfield. Fig. 2 *b* of my present plate is the representation of a specimen of my own found by myself in the Red Crag at Sutton many years ago, and this I now think is only a slight distorted form of *tortuosus*, as I have two others similar in the volutions, but not so perfect, and thought it only a variety, not of sufficient importance to deserve a figure; but so many separations having been made out of a group of shells which probably may be united under the name of *Sipho*, I have had it here figured and have endeavoured to group these shells together under that name, which have been found in the Upper Tertiaries of the east of England, viz.:

Trophon (Sipho) Islandicus? *Chem.* 2nd Sup., tab. ii, fig. 3. Red Crag.
— — Olavii, *Beck.* Crag Moll., vol. i, p. 46, tab. vi, fig. 10 *a, c.* Red Crag.
— — gracilis, *Da Costa.* 2nd Sup., tab. ii, fig. 4. Cor. Crag.
— — propinquus, *Alder.* App. Crag Moll., tab. xxxi, fig. 3 *a. b.* Cor. Crag.
— — id. Sup., tab. vii, fig. 21, sinistral. Red Crag.
— — id. 2nd Sup., tab. ii, fig. 5. Cor. Crag.
— — Sarsii, *Jeff.* Sup., p. 23, tab. i, fig. 9. Red Crag.
— — tortuosus, *L. Reeve.* Crag Moll., vol. i, tab. vi, fig. 10 *b.* Red Crag.
— — id. Sup., tab. ii, fig. 15 *a.* Red Crag.
— — id. 2nd Sup., tab. ii, fig. 2 *a, b.* Red Crag.
— — Sabini, *Hancock.* Sup., tab. ii, fig. 15 *c.* Bridlington.
— — ventricosus, *Gray.* Sup., p. 22, tab. iii, fig 4. Bridlington
— — Leckenbyi, *S. Wood.* Sup., p. 24, tab. vii, fig. 1. Bridlington.

The whole of these may very probably be only inconstant varieties of *Islandicus*, but I have figured them under the names of their authors to show their occurrence in the deposits embraced by my Monograph. *T. Leckenbyi* of myself stands in this respect on an equal footing with the other so-called species given above.

Note.—Sipho, Klein, 1753. This name is previous to our starting point, the 12th edit. of Linné, but it appears now to be adopted by many of our conchologists.

Trophon pseudo-Turtoni, *S. Wood.* 2nd Sup., Tab. II, fig. 1 ; and Tab. IV, fig. 1.

Trophon Norvegicus ? *Chemn.* Appendix to Crag Moll., t. xxxi, fig. 1 ; 1st Supplement to Crag Moll., t. v, fig. 14 ; and Addendum Tab., fig. 16.

Locality.—Red Crag, Waldringfield.

In the Appendix to the Crag Mollusca and in my previous Suppl. are figured and described some specimens of this shell, none of them perfect, under the name of *Trophon Norvegicus.* The perfect specimens which I am now able to represent seem to me to differ so considerably, however, from the recent shell called *Norvegicus,* that I have proposed for it the above name, indicative at once of its distinctive character from *Norvegicus* and of its affinity to that species. Our present shell possesses more convex volutions and a much deeper suture, a longer spire with a smaller and shorter opening. The recent shell *Norvegicus* is described as having " the body whorl disproportionately large compared with the spire ;" " the body occupies $\frac{3}{5}$ths of the dorsal length." The body whorl of our present fossil measures only half of its entire length, and is also more strongly striated ; for assuming even that it has been decorticated and lost some of its outer coating, these striæ are more visible than those on the living shell, which on a specimen in my possession are principally confined to the epidermis, or at least are but very slightly visible beneath it. I am anxious to have this fossil correctly described and delineated because in a list of fossils from Uddevalla, by Mr. Jeffreys, read at the Brit. Assoc. 1863, at p. 77, is the name of *Fusus Turtonii,* Bean, with this remark "a var. approaching in shape *F. Norvegicus;*" and I imagine this Uddevalla fossil may possibly be the same as our present specimen. I cannot, however, fairly refer the shell figured to either of those species ; and it appears to me to be intermediate between the two. The late Dr. S. P. Woodward in his list of shells from the Norwich crag has the name of *T. Norvegicus* (J. M. and R. F.) which as well as the one called by Mr. Bell *F. Lagillierti* (Sup. to Crag Moll., Addendum Plate, fig. 16), may also, I imagine, be the same as the present shell.

The specimen figured, Tab. IV, fig. 1, is from the Ipswich Museum by the kindness of Dr. J. E. Taylor, the curator.

Trophon (Tritonofusus) altus, *S. Wood.* 2nd Sup., Tab. I, fig. 11. Crag Moll., vol. i, Tab. VI, fig. 13, as *Trophon altum.* 1st Sup., p. 23, Tab. II, fig. 17.

To whatever genus this shell may belong, the specimens exhibit great variation like

those of *Buccinum undatum* and *Trophon antiquus*. A further figure which I have now given shows the canal not to be prolonged beyond the lower portion of the outer lip, corresponding in that respect to the diagnosis of the genus *Buccinum*. Some of the specimens I have figured and referred to this species have on the upper portion of the spire some obsolete costæ, which are absent from our present specimen; but this, I think, is insufficient for specific removal, as the same differences may be seen in specimens of the common *Buc. undatum*.

The specimen now figured is from the cabinet of Dr. Reed, who obtained it from Mr. A. Bell, by whom it had been labelled as a new species from the Red Crag, Butley, which was one of the reasons that induced me to have it figured. It is a very perfect specimen, and shows an expanded lip like that of *Buccinum*.

TROPHON (BUCCINOFUSUS) KRÖYERI ? *juv. Moller*. 2nd Sup., Tab. III, fig. 8.

FUSUS KRÖYERI, *Möll.* Index Moll. Grœnlandiæ, p. 15, 1842.

Axis 1 inch.

Locality. Red Crag, Shottisham.

The present specimen has been sent to me by Mr. Robert Bell with the above name, and I give it on his authority; he says he has compared it with a recent specimen of the above name in the British Museum, and it appears to him to correspond with the younger or upper part of that species. I saw that species in the British Museum some years ago, and so far as my memory will assist me, I think probably it may be so. I have given to it the above name with a mark of doubt, as it will be necessary to have a better specimen for a more correct determination. The specimen is without striation, or otherwise the striæ have been obliterated.

FUSUS WAELII, *Nyst*. 2nd Sup., Tab. I, fig. 10 *a*, *b*, *c*.

FUSUS WAELII, *von Könen*. Mitt. Oligoc., p. 76, taf. vi, fig. 2 *a—d*, 1867.
— — *S. Wood*. Quart. Journ. Geol. Soc., vol. xxxiii, p. 120, 1877.

Spec. Char. F. Testâ elongato-fusiformi, spirâ elevatâ, apice obtusâ; anfractibus convexis, longitudinaliter costatis, spiraliter striatis; aperturâ ovatâ; canali, elongato paulo contorto terminato.

Axis, 1 inch.

Locality. Cor. Crag, ? Boyton.

This shell was noticed by me as from the Coralline Crag in the 'Quart. Jour.' of the Geol. Soc. above referred to, and I have now the opportunity of figuring the specimens. I have also since then received two specimens of the typical oligocene form from Dr. Nyst, from the locality of Baesele, near Boom (Rupelien); and I think the British Crag Fossil may safely be referred to it. The only difference which I can detect is that the inside of the outer lip in one of the Belgian specimens is denticulated, while that of the Crag shell is not. The other specimen sent to me by Dr. Nyst, however, does not present this character; nor so far as I can see do specimens sent me by Dr. Von Könen, from the German Oligocene of Sternberger Gastein, nor by some specimens from the Oligocene of Rupelmonde, in Belgium, sent me by M. Rutot; the artist has given a representation to my specimen which might be mistaken for denticulations on the inside of the outer lip, but there are none, and the ribs are not so wide and coarse as he has shown them. I have had the only two specimens (which I believe have as yet been found) figured, one of which is more elongated than the other, and they appear to correspond as well with the two figures given by Dr. Von Könen as with the oligocene specimens to which I have referred. Our shell has eight, somewhat rounded ribs or costæ upon the last volution, the spiral striæ resemble those upon the Baesele shell, and the caudal termination is long and slightly twisted as in the one before mentioned; the apex is obtuse, with the first volution apparently smooth, but the volution not being perfect this cannot positively be affirmed. This shell also very strongly resembles *Fusus crispus*, and a worn specimen was figured by me in my first Suppl. under that name, with a note doubting the correctness of the reference (p. 29, Tab. II, fig. 10). Two specimens with the name of *F. crispus*, Broc., and the syn. *F. Rothi*, and the locality Bekken (miocene) attached, I have, by the kindness of M. Bosquet, long possessed, and these show prominent and sharp spiral striæ, with two small ridges upon the columella; but these ridges are not visible in the only two worn specimens from the Crag, on which I made the reference in p. 29 of my Suppl. A fine specimen of *F. crispus*, Borson, sent me by Dr. Von Könen, from the Miocene of Langenfelde near Hamburg, has the inner part of the outer lip denticulated, but has no folds on the columella; in other respects it agrees with specimens sent me from the bed at Kiel and Edeghem in Belgium, under the name *F. sexcostatus*. A specimen of *F. sexcostatus* from the Miocene of Dingden near Wesel, kindly sent me by Dr. Könen is destitute of these folds on the columella, and were it not that the three upper whorls are smooth (which is not the case with the Crag specimens), would equally agree with the more elongated form of the two now given specimens figured above. On the other hand, specimens sent me by M. Rutot, under the name of *F. sexcostatus*, from the so-called Miocene of Kiel and Edeghem in Belgium, with the apices perfect, are destitute of these three unornamented whorls; but one of them has two folds on the columella; another (the largest) has but one, while another, the smallest, has none at all. Not one of these three last-mentioned specimens has the inside of the outer lip denticulated, and the

smallest of them is not distinguishable in any respect from the longer of the two Crag specimens which I have figured under the name of *Waelii*. Under these circumstances it seems to me that, though *F. Waelii* is not recognised as a species of the Belgian Miocene (a formation which M. Vanden Broeck now refers to the oldest Pliocene, contending that the true Miocene is absent in Belgium), the shell I have figured under this name does occur in the Belgian formations; and it may perhaps be that, if a large series of specimens of *F. Waelii*, *F. crispus*, and *F. sexcostatus*, were compared with each other, it would be impossible to separate them into distinct species.

The specimens present all the appearance of genuine fossils of the Coralline Crag, though from their locality (see footnote, p. 3) a question may attach as to this.

Fusus ? obscurus, *S. Wood.* 2nd Sup., Tab. I, fig. 12 *a*, *b*.

Axis, $\frac{7}{8}$ths of an inch.

Locality. Cor. Crag,? Boyton.

A single specimen, to which I have given the indefinite or undefined generic name of *Fusus*, was kindly sent to me by Mr. R. Bell. Although the shell is perfect it is decorticated throughout, and it is impossible to say whether it was, in its perfect condition, striated or not; but in its present state I cannot discover any trace of striæ upon it. I give it therefore under the above name from its uncertain characters.

Fusus? exacutus, *S. Wood.* 2nd Sup., Tab. II, fig. 18.

Locality. Cor. Crag, Sutton.

Our present figure represents only a fragment of a shell which has been in my Cabinet for many years. It was found by myself at Sutton in the upper portion of the Coralline Crag, and I have kept it hitherto unfigured in the hope of a better specimen turning up. On the left or columella side of the aperture is the impression of what appears to have been that of the fleshy lobe of the animal, but it is not represented in the engraving. The large opening in the outer lip is too low for a sinus, and is, I believe, simply a fracture. I think the specimen belongs to the genus *Fusus* and not to *Pleurotoma*. I now figure it because at my advanced age I must relinquish the hope of seeing a more perfect specimen.

Fusus nodifer, *A. Bell*, MS. 2nd Sup., Tab. III, fig. 4 *a*, *b*.

Locality. Red Crag, Waldringfield.

The specimen here represented is from the Cabinet of Dr. Reed, and was obtained by Mr. Alf. Bell, who had affixed to it the above name and the following description :— "Shell fusiform, volutions 5, convex, with a ridge at the section, and eight or nine rounded ribs covered with coarse spiral striæ." The specimen is much rubbed and worn, and it is doubtless derived from an older formation.

At p. 117 of my first Supplement reference is made to the name of *Fusus despectus*, Linn., which has been given in the list to the paper of Mr. Prestwich as a species new to the Crag, and also in Mr. A. Bell's list of Crag shells. I have made every endeavour to ascertain where the specimens are upon which this name has been founded, but without success. In my large series of the abundant Red Crag shell, *antiquus*, nearly every form of exterior ornament, from the very finely striated specimens to such as are ornamented with large and prominent spiral ridges, like those upon *F. despectus* ('Ency. Meth.,' pl. 426) may be seen ; but this latter shell in the recent state has apparently a slightly curved outer lip, and this variety I have not seen from the Crag. *Fusus tornatus*, Gould, is another proximate form, but in this the canal seems to be a little more oblique than in that of the Crag shell, and if these characters be the only differences all three might, I think, be united as varieties of one species.

Mr. Jas. Reeve has recently sent to me a specimen from the Norwich Museum which, he says, was found at Bramerton ; the name of *Fusus antiquus* accompanied the shell, and in this I believe he is perfectly right. It appears to have lost the whole, or very nearly so, of the thick outer layer of the original shell, and in its present state, it somewhat resembles what I have called *Trophon altus*, so much so that if it had been *entirely* denuded by the removal of the outer shell it could not have been recognised for what it really is. So many specimens from the Crag have suffered more or less by the removal of either the outer layer of the shell, or partially so in the destruction of some of its ornamentation, that I mention this case as an instance of the liability to which palæontologists are sometimes misled, by such alterations in the condition of the shell into the adoption of new species or of new identifications.

A specimen also from Dr. Reed has recently been sent to me with a label on which is written "*Fusus antiquus*, L., Cor. Crag, Broom Pits, near Orford, from the upper beds." This is nothing but a recent specimen filled with and partially stained on the surface by the Cor. Crag material. I have not yet seen this species (*antiquus*) from the Cor. Crag. The shell which I have figured as *Trophon elegans*, is in the list of Mr. Prestwich's paper, p. 492, called a variety of *antiquus ;* but so far from assenting to that

reference, I rather believe the shell to be the type of a new Genus, as suggested by Mr. Charlesworth, who figured and described it in the 'Mag. Nat. Hist.,' vol. i, p. 219, fig. 23; as it has asmall apex, and a deposit of calcareous matter on the upper part of the left lip.[1]

MUREX REEDII, *S. Wood.* 2nd Sup., Tab. I, fig. 9 *a*, *b*.

MUREX REEDII, *S. Wood.* Quart. Journ. Geol. Soc., vol. xxxiii, p. 120, 1877.

Spec. Char. Testâ fusiformi, crassa; spirâ elevata; apice acutâ, anfractibus septenis subangulatis; varicibus tenuibus, sublamellosis, ultimo anfractu maximo; aperturâ ovatâ, labro intùs incrassato dentato; columellâ incurvata.

Length, $1\frac{5}{8}$ths inch.
Breadth, $\frac{7}{8}$ths inch.
Locality. Cor. Crag? Boyton.

A specimen is among the shells sent to me by Dr. Reed, and from the perfection in which it was found, I am enabled to make a fair comparison of it with other shells of this genus in similar condition. It has prominent varices, which are not much foliated. It somewhat resembles *M. tripartita*, but is more elongated, and differs from it in not having spiral striæ like that shell, or like the long known Crag shell *M. tortuosus*, J. Sow., which is covered with large and prominent spiral striæ or ridges.

The artist's representation (figs. 9 *a*, *b*, of Tab. 1) might raise the idea that our present shell was obscurely striated, but I can detect no striation, though there are some faint transverse marks between one pair of varices, and as the shell is in such a fresh and unworn state it may be safely said that it never possessed striations. I have endeavoured by sending accurate drawings of the shell to Dr. Nyst, and several other Belgian conchologists, to ascertain whether anything like it was known from the Belgian beds; but they all assure me that they know of nothing like it. The canal and mouth are slightly oblique (a feature which the artist has failed in the engraving to catch), and there are six varices on

[1] I may mention here that a dead and bleached specimen of *Conus tulipa* was once showed to me, and said to have been found in the Cor. Crag at Ramsholt; and I have also seen a very pretty (fabricated) shell as a Red Crag fossil from Walton-on-the-Naze. This was a thick specimen of *Buc. Dalei*, beautifully ornamented with elevated ridges in a *Harpa*-like fashion, and executed in a very skilful manner, but the artist had left unobliterated a few small marks of his graving tool. These specimens are probably still in existence, and I mention them here like that of *Fusus antiquus* from Orford by way only of caution.

the body whorl and upon the preceding volution. The apex probably was sharp, but the specimen is there slightly broken. The shell is not quite so robust in proportion to its length as the artist has represented it. It somewhat resembles *M. Haidingeri*, from the Vienna beds shown in Tab. 23 of Dr. Hornes' work; but his figure differs from our present shell in having no denticulations on the outer lip, and in having the varices strongly continued down the canal.

In consequence of the unsatisfactory representation to which I have referred, I annex a cut made from a drawing which shows the characters of the shell more accurately.

The appearance of the specimen is not at all suggestive of its being a derivative; and though obnoxious to the uncertainty which I have before (p. 3) mentioned as attaching to the specimen from Boyton, the specimen presents altogether the appearance of a genuine fossil of the Coralline Crag.

MUREX PSEUDO-NYSTII, *S. Wood.* Tab. I, fig. 8 *a*, *b*.

M. Testâ elongato-fusiformi, crassâ; spirâ elevatâ, anfractibus septenis, convexis; supernè subangulatis, spiralite rlatè striatis; varicatis, varicibus, 7—10, *tenuibus, lamellosis, compressis; ultimo anfractu equaliter longiore; aperturâ ovatâ, canaliculata, canali attenuato, labro intus pauci denticulato.*

Axis, $1\frac{1}{8}$th of an inch.

Locality. Cor. Crag? Boyton.

A perfect specimen as above represented has been sent to me by Dr. Reed, and so far as I am able to ascertain it appears to be specifically distinct from any previously described species. The shell may be described as elongately fusiform, with seven or eight convex volutions, the upper part of these somewhat depressed, giving a slight shoulder to the volutions; coarsely striated in a spiral direction, but above the shoulder these striæ do not extend: the apex was probably sharp and acute, but it is slightly broken; aperture small and ovate, and the outer lip extremely thick; and on which there were two prominent denticles, and one nearly obsolete on the lower part of the inner lip; it has a long canal, slightly curved, and open. The first two volutions appear to be smooth or destitute of marking either spirally or longitudinally.

I have compared it with specimens of Von Könen's species *Nystii*, kindly sent me by Dr. Nyst, and with others from Edeghem, in Belgium,[1] sent me by M. Rutot, and although it approaches that shell in several respects, it does not do so sufficiently to justify any identity with it. Nevertheless, to indicate its affinity I have assigned it the

[1] This deposit of Edeghem has hitherto been regarded as miocene, but it is placed by M. E. Vanden Broeck with that of Kiel and some other localities near Antwerp as oldest Pliocene "Esquisse Géologique et Paléontologique des depots Pliocénes des environs d'Anvers," p. 35.

above name. *Nystii* is a less tapering shell, and possesses only half the number of varices, and these more thick and prominent than those of our present shell.

The same remark in reference to the genuineness of the shell as a species of the Coralline Crag, which I have made in the case of the last described species (*Reedii*), applies to the present case.

Two imperfect specimens, or rather the larger portion of some small species belonging to this genus, were found by myself many years ago in the Cor. Crag of Sutton, and were retained in the hope that something better would turn up to enable me correctly to describe them, or to refer to some previously described species. These are shown in figs. 7 *a*, *b* of Tab. I, and exhibit the last volution with the aperture and its straight canal perfect; and as these constitute the principal portion of the shell, a fair idea of it may be thus formed. The specimens very much resemble *Murex Canhami*, figured in No. 14 of Tab. VII of my first supplement in their coarse spiral striations, but they have not the prominent points or shoulders to the varices which that shell possesses, and their canals are straight and narrower than that of *Canhami*. In their imperfect state I have here called them provisionally *Murex recticanalis*.

MUREX CROWFOOTII, *S. Wood*. 2nd Sup., Tab. I, fig. 15.

Locality. Cor. Crag, ? Boyton.

The specimen figured is imperfect, as shown by the fragment of the last whorl which remains adherent to the preceding one, but in other respects is in finely preserved condition. The cross striation, which is very thick and strong, resembles that in *M. tortuosus*, but the form of the shell is much less elongated, and the number of distinct whorls preserved would seem to indicate that, when perfect, the specimen could be only that of a much smaller shell than *tortuosus*. As it was placed in my hands by Mr. W. M. Crowfoot, to whom it belongs, I have given it under the name of *Crowfootii*, which will also serve to indicate the ownership of the specimen, for comparison in the event of any one more perfect turning up. I am informed by Mr. Robert Bell that he has obtained many specimens of *M. tortuosus* from the Coralline Crag, which confirms my belief that this species which was long known from the Red Crag only, is merely present as a derivative in that formation.

TRITON CONNECTENS ? *S. Wood*. 2nd Sup., Tab. I, fig. 14 *a*, *b*.

TRITON HEPTAGONUS, *S. Wood*. Crag Moll., vol. i, p. 41, tab. iv, fig. 8, 1848.
„ CONNECTENS, *id*. Supplement to Crag Moll., p. 30, 1872.

Axis, 1 inch.

Locality. Red Crag, Waldringfield.

A specimen of this genus has been sent to me by Mr. R. Bell, which he says is from

Waldringfield, that receptacle for so many derivatives; and as this shell is very rare to my researches, and the present specimen presents differences from the one previously represented, I have had it figured as above. It is doubtless derivative.

RANELLA ? ANGLICA, *A. Bell.* 2nd Sup., Tab. III, fig. 3.

RANELLA ANGLICA. *A. Bell.* Ann. and Mag. Nat. Hist., May, 1871.

Spec. Char. "Shell small; whorls 3, 4 (apex wanting), convex, with coarse elevated ridges on the bottom whorl, crossing the periodic growths (which are very distinct), and extending to the mouth, becoming very marked at the base; mouth angulated above, outer lip spreading towards the base, where it is sharply angulated by one of the ridges; pillar reflected; canal rather open; umbilical chink small."—*A. Bell.*

Length, $\frac{6}{10}$ths of an inch.

Locality. Red Crag, Waldringfield.

The only specimen of this shell which has been obtained, so far as I know, is the one now figured. It is from Dr. Reed's collection, and was described as above by Mr. A. Bell. It is not in a perfect condition, and I am doubtful of the correctness of the assignment, but have thought it best to have it figured, and give it under Mr. A. Bell's name and description. It is no doubt derived from some antecedent formation, and seems to me to resemble a good deal the imperfect specimen from the Cor. Crag, figured by me in Tab. II of my first Suppt., under the name *Murex corallinus*. There are some spiral striæ or ridges on the base or lower part of the volution, but the specimen is too much mutilated on the spire to show whether it was covered entirely with striæ. There are three or four distinct denticles on the inside of the outer lip, as in *M. corallinus*, and a few coarse ridges on the outside of this outer lip, as if the spire had also been so covered.

PLEUROTOMA MORRENI, *De Konninck.* Tab. II, fig. 6 *a*, *b*.

PLEUROTOMA MORRENI, *De Kon.* Desc. Coq. Foss. de Basele, p. 21, pl. i, fig. 3, 1837.
„ „ *Nyst.* Coq. Foss. de Belg., p. 510, pl. xl, fig. 6 *a*, *b*, 1843.
„ INTORTA (?), *Bellardi.* Foss. del Piedm., p. 16, tav. i, fig. 13, 1847.

Axis, $1\frac{1}{4}$ inch.

Locality. Red Crag, Waldringfield.

The specimen as above represented is from the Cabinet of Mr. Canham, who

tells me he obtained it from the well-known phosphatic nodule pit at the above-named locality.

M. Nyst, as also M. de Konninck, appear to think the shell referred to is a species distinct from *Pl. intorta,* Broc.; and as the Belgian shell seems not to be rare, and to have been found in good preservation, probably they have good means for such determination. In ' Crag Moll.,' vol. i, tab. vi, fig. 4, I figured two specimens of which the smaller one may possibly be the same as our present shell, except that it is more elongated and has a less pointed termination, and as I am not imposing a new name I have thought it best to figure and describe our present shell which, however, much resembles fig. 13, tab i, of M. Bellardi's paper. This naturalist, however, seems to consider the shell so figured by him as only a variety of Brocchi's species.

The Waldringfield specimen is doubtless derivative, but from what formation it has come is, of course, conjectural. Considering, however, the close resemblance of the Cor. Crag shell which I have figured under the name *Fusus Waelii* to a shell which occurs at Baesele, (the locality from which De Konninck describes our present species,) it is quite possible that our present shell may be among the many yet unrecognised species of the Cor. Crag which by the destruction of this Crag have gone to fill that museum of derivatives which the Waldringfield Red Crag accumulation constitutes.

PLEUROTOMA CURTISTOMA? *A. Bell.* 2nd Sup., Tab. II, fig. 9, *a, b.*

PLEUROTOMA CURTISTOMA, *A. Bell.* Ann. and Mag. Nat. Hist., 1871, p. 7.

Axis, 1 inch.

Locality. Cor. Crag? Boyton.

The shell represented has been recently sent to me by Dr. Reed, and it was, he tells me, obtained from the above-named locality. In colour it resembles the Coralline Crag. From the description given by Mr. Bell I have referred it doubtfully to *curtistoma,* but I have not had for examination the specimen to which Mr. Bell assigned that name, which I believe has gone into the British Museum. He gives for it the locality Cor. Crag, Gedgrave. The shell now figured is closely connected with one that I figured in my first Suppt. under the name of *Pleurot. Bertrandi* (?), Addendum Plate, fig. 4, p. 179, but it has a smaller and shorter aperture. In Mr. Prestwich's List, p. 494, *Pl. curtistoma* is given as a variety of *Pleurot. attenuata.* I think, however, that our shell is distinct, as it is not attenuated and has a shorter aperture, but more and better specimens than I have seen will be necessary for certain determination.

PLEUROTOMA TERES ? *Forbes*. 2nd Sup., Tab. II, fig. 7, *a*, *b*.

PLEUROTOMA TERES, *Forbes*. Ann. and Mag. Nat. Hist., vol. xiv, p. 412, pl. x, fig. 3.
MANGELIA TERES, *Forbes and Hanb*. Brit. Moll., vol. iii, pl. cxiii, figs. 1, 2.
DEFRANCIA TERES, *Jeff*. Brit. Conch., vol. iv, p. 362, pl. lxxxviii, fig. 5.

Axis, $\frac{5}{16}$ths of an inch.

Locality. Cor. Crag, Sutton.

A small and worn specimen was found by myself some years ago in the Cor. Crag of Sutton, which I have kept unfigured in the hope of obtaining another and better preserved specimen to assist in its correct determination, but without success. I now give it as above, but with a mark of doubt; and it is evidently distinct from *tereoides*, 'Supplement to Crag Moll.,' Addendum Plate, fig. 3 *a*, *b*. In the 'Crag Moll.,' vol. i, tab. vi, fig. 6, is figured a minute shell with a peculiar ornamentation on the young or upper volutions; this was called *Trophon paululum*, and considered as the young of a larger shell. In Professor Prestwich's paper, 'Quart. Journ. Geol. Soc.,' vol. xxvii, p. 146, this is referred to *Pl. teres*, which probably it is (see 1st Supplement to Crag Moll.,' p. 27). My present specimen is somewhat abraded, and shows more numerous and close spiral striæ than the recent *teres* usually presents. These in my specimen are not carried over the ribs, but this may be due to obliteration from wear; the ribs also are more prominent than in the recent shell. On the other hand, the form of the shell, and its deep and broad sinus, agree with the recent species. The striæ on the lower whorls are rather more numerous than represented by the engraver.

PLEUROTOMA GRACILI-COSTATA, *S. Wood*. 2nd Sup., Tab. II, fig. 8.

Spec. Char. Testâ ovato-fusiformi, ventricosâ, brevispirâ, acuminatâ; anfractibus convexis, longitudinaliter et angustè costatis; transversim striatis; ultimo basi sulcato; columellâ canalique brevi, contortis; aperturâ ovatâ.

Axis, $\frac{5}{8}$ths of an inch.

Locality. Cor. Crag, Sutton.

The specimen figured was found by myself many years ago, but from its peculiar appearance I postponed noticing it, hoping that something better might turn up to assist in its determination. It occurred to me that the costæ or ribs which are formed by the periodical arrest of the outer lip during growth might have been originally

round and hollow, and that the upper part of them had been decorticated, and a portion consisting of the two sides of the original ribs only left, the effect of which would be to show a number of thin sharp, instead of half that number of wide and blunt costæ. The apex is sharp, the three first volutions being without riblets, and the fourth volution has 4 or 5 rounded riblets, beyond which these riblets are double in number. My specimen is not sufficiently perfect to show if there have been any spiral striæ. The outer lip is much curved and there is a large deep sinus a little below the suture; the outer lip is also sharp, without any striæ or ridges on the inside of it. My specimen resembles the figures given by M. Nyst with the name of *Pleurot. acuticosta* ('Coq. foss. de Belg.,' p. 529, pl. 42, fig. 5), but that figure is indifferent, and the description is too short to supply the deficiency. *Pleurot. incrassata* from Touraine somewhat resembles our shell, but I have not a specimen for comparison. The above name is given provisionally.

PLEUROTOMA ICENORUM, *S. Wood.* 2nd Sup., Tab. III, fig. 8, *a*, *b*.

PLEUROTOMA ICENORUM, *S. Wood.* 1st Supplement Crag Moll., p. 35.

Locality. Cor. Crag near Orford.

There is so much doubt and difficulty about this shell that I find it necessary to give another figure of it, from a perfect specimen in my own cabinet. My shell has a row of nodules formed at the projecting portion of the outer lip, with a row of smaller nodules adjoining the suture; thus making two rows on all but the lower volution. The two apical whorls are quite smooth and without ornament, making the apex very obtuse; differing thereby from the representation of *Pl. coronata* of Bellardi. At the base there is an umbilicus caused by a slight obliquity of the volutions outwardly. Two specimens have been sent to me from Dr. Reed's collection with the name of *Pl. umbilicata*, A. Bell, which correspond with *Icenorum*. Our shell has unfortunately had several names. In Mr. Prestwich's list, p. 145, it is called *Pleurotoma galerita*, Phil. In Mr. Bell's List of the English Crags, p. 35, it is said to have been figured and named by Dr. von Könen as *Pl. Hosiusii* ('Mioc. Nord. Deutch. Moll.,' p. 105, taf. 2, fig. 12 *a*, *d*). These foreign species appear to me (judging from representations) to be different from our shell, which has an obtuse apex and an umbilicus, neither of which is possessed by them. The name of *Pl. semicolon*, given in Crag Moll., is also erroneous for the reasons mentioned in my first Supplement, p. 35. I would have adopted Mr. Bell's name of *umbilicata*, were it not that the shell to which I had previously assigned the name *Icenorum* is, in my opinion, the same species.

PLEUROTOMA SENILIS, *S. Wood.* 2nd Sup., Tab. III, fig. 2 *a, b.*

PLEUROTOMA SENILIS, *S. Wood.* 1st Supplement, p. 42, tab. v, fig. 5.
— ARCTICA ?, *Adams.* — — p. 45, t. vi, fig. 9.
— VIOLACEA, *M. & A.* — —

Locality. Red Crag, Sutton and Waldringfield.

The original specimen, figured in my first Supplement, was very much worn, but some better preserved specimens from the Red Crag have been obtained by Mr. Canham. That which I have now figured as 2 *b* was the most perfect, and has since been lost by him, but having while it was in my hands had a drawing made of it I am enabled to give the figure 2 *b* from this. The specimen figured in Tab. V of my first Suppl. was so much rubbed that some uncertainty attaches to its identification with the shells now figured, and under these circumstances it is our present shell that I desire to distinguish by the specific name of *senilis.* The fragment, No. 9, figured by me in Tab. VI of my first Suppl. under the name of *arctica,* seems to be one of a much worn specimen of the present species. They are all derivative in the Red Crag, but may, I think, not improbably have been derived from the Coralline, though nothing identical with them has yet been obtained from that formation. Under the circumstances explained above, I have removed the name of *P. violacea* from my Synoptical list.

PLEUROTOMA CATENATA, *A. Bell,* MS. 2nd Sup., Tab. III, fig. 5.

Axis, $\frac{9}{16}$ths of an inch.

Locality. Cor. Crag, Gedgrave.

The above figure is taken from a specimen in the Cabinet of Dr. Reed, which was obtained from the Cor. Crag by Mr. A. Bell, who had assigned it the above name in MS.

There is so much uncertainty attending many identifications of the species of this genus that I prefer giving the figure of the shell with Mr. A. Bell's assignment of it to expressing any opinion of my own about it.

The shell has eight volutions, very slightly convex, indeed nearly flattened; apex obtuse; embryonic whorls smooth; there are two rows of nodules, above which is the sinus and two smaller spirally nodulous lines; base of volution covered with prominent spiral lines; aperture ovate, with a canal of moderate length; the ornamentation, though not very well defined, appears to be its only distinction. The specimen figured is the only one which I have seen, and is by no means perfect.

PLEUROTOMA PANNUS, *Basterot.* 2nd Sup., Tab. III, fig. 6.

PLEUROTOMA PANNUS, *Bast.* Foss. du Sud-ouest de la France, p. 63.
— — *Bellardi.* Monog. delle Pleur., p. 27, tav. ii, fig. 2.
— DUMONTII, *Nyst.* Belge Foss., p. 527, tab. xlii, fig. 4.

Spec. Char. "*P. striis transversis, numerosis, minutis; striis incrementi decussatis.*" —Bast.

Axis, $\frac{5}{8}$ths of an inch.

Locality. Cor. Crag, near Orford.
France: Saucats, Léognan, Dax.
Piedmont: Torino, Colli Tortonesi.

The specimen figured, which, however, is not quite perfect, was found near Orford by Dr. von Könen; and he has kindly sent me a specimen of the same species from Antwerp, which seems to correspond with our Crag shell. Mr. A. Bell has introduced this name into his list of Coralline Crag shells, so that probably several other specimens may have been found, but that in my possession is the only one from the Crag that I have seen. *Pl. catenata* of Mr. Bell strongly resembles it, and may be only a variety.

As with so many species of this variable genus, it is difficult to say whether the distinctive features which induce authors to make specific distinctions are in the present case constant; but the identification of the shell by so good a conchologist as Dr. von Könen, and the production by him of a specimen from Antwerp identical in character with our Cor. Crag specimen, gives me more confidence in the present identification than I should otherwise entertain.

The specimen figured as No. 1 of Tab. III was sent to me by Dr. Reed, and has a label attached with the name of *Borsonia prima* assigned by Mr. A. Bell, who gives for it the locality of "Red Crag, Waldringfield." The shell looks like a deformity, and the ridge upon the columella accidental, as it is angular in form, and like a simple projection. The shell is much abraded, and appears like a mutilated specimen of *Pleurotoma turrifera*, Nyst (*P. turricula* of Brocchi, figured in 'Crag Moll.,' Tab. VI). As the name *Borsonia prima* may, perhaps, be introduced into lists of shells from the Crag, I think it best to give a figure of the specimen, to enable others to judge for themselves.

Borsonia prima, Bellardi, 'Monog. Pleurot. Foss.,' pl. iv, fig. 13, is, I think, a different shell altogether.

A specimen of *Pleurotoma* from Boyton has been very recently sent to me by

Mr. Cavell, of Saxmundham, which closely corresponds with *Pleurot. lævigata*, Phil., being quite destitute of costæ; but the shell cannot be described as "lævissima," as there are vestiges of spiral striæ remaining upon the Crag specimen. This is possibly the same as fig. 12, tab. vii, of 'Crag Moll.,' but it is distinct from fig. 15, tab. vi, of my first Supplement, which I think may be referred to *P. nebula* of Mont.

CANCELLARIA (ADMETE) AVARA? *Say*. 2nd Sup., Tab. IV, fig. 5.

COLUMBELLA AVARA, *Say*. Gould. Invert. Massach., p. 313, fig. 197.
CANCELLARIA AVARA, *A. Bell*. Ann. and Mag. Nat. Hist., May, 1871.

Axis, $\frac{1}{2}$ an inch.

Locality. Red Crag, Waldringfield.

This is another imperfect and much worn specimen from Dr. Reed's Collection, but as it has been published by Mr. Bell in his list of Crag shells as a species of that formation, I have had it figured as above. I am unable to give a full description of the specimen from its mutilated condition, but it possesses several folds or small ridges upon the columella, from which, and its general form, it seems referable to that group of the Cancellariæ to which the subgeneric name *Admete* has been given, but beyond that I can express no opinion of its identity, and I give it under the name *Avara* solely on the authority of Mr. Bell. It appears to me like a derivative. I have a very imperfect specimen of an elongated species of *Cancellaria* from the Coralline Crag, but it is too much mutilated to permit of its being even provisionally described. It does not, however, appear to have belonged to the same species as the above shell.

CANCELLARIA CRASSISTRIATA, *A. Bell*, MS. Tab. III, fig. 16 *a*, *b*.

Axis, $\frac{1}{2}$ an inch.

Locality. Red Crag, Waldringfield

The figure is taken from one of two debauched specimens from the Red Crag of Waldringfield in Dr. Reed's Cabinet, which were obtained for him by Mr. A. Bell, and who has sent me the following rough note upon them:—"Specimens much worn and decorticated. There are about ten striæ on the body whorl, the most prominent being three on the most extended part of the volution, crossed by some broad obscure ribs; the outer lip is thickened inside at the top; inner lip reflected upon the pillar, showing in worn specimens an umbilical chink. The absence of teeth on the inner lip would place the shell in the section *Admete*." Whatever the specimens may prove to be, they are evidently derivative in the Red Crag.

CERITHIUM VARICULOSUM, *Nyst.* Crag Moll., vol. i, p. 69, Tab. VIII, fig. 3; 2nd Sup., Tab. II, fig. 15.

Locality. Red Crag, Walton Naze.

The figure given of this shell in the 'Crag Moll.' does not quite correctly represent the fossil found at Walton Naze, which in Prestwich's list is referred to *Cerithium reticulatum*, but which I believe is specifically distinct; the volutions of my fossil are more convex, and are not only destitute of thickened varices, but have a different ornamentation from the recent shell. I have now figured a fragment found by myself at Walton Naze; and this has decidedly convex volutions, with three spiral and nodulous ridges, and a small one at the base; moreover, these spiral ridges are not equally distributed over the whorls, there being a wider space between the upper one and the suture, than there is between the others. In *C. reticulatum* the volutions are nearly flat and have four equidistant nodulous striæ. I have therefore retained the shell under the name originally given.

CERITHIUM GREENII? *Adams.* 2nd Sp., Tab. IV, fig. 16.

CERITHIUM GREENII, *Adams.* Bost. Journ. Nat. Hist., vol. xi, p. 287, pl. iv, fig. 12.

Locality. Chillesford Bed, Bramerton.

Two small but very perfect specimens of some species of the genus *Cerithium* have been sent to me by Mr. Reeve with the locality of "Upper bed at Bramerton." I have a difficulty in referring them to anything previously described, and have therefore given them provisionally the above name. The shell to which they present the nearest approach is *Cerithium Greenii*, C. B. Adams, figured and described by Gould ('Invert. Mass.,' p. 279, fig. 184), but I have not the recent shell to compare with it. In 'Brit. Conch.,' vol. iv, p. 267, it is said that *C. Greenii* is the same as *Cerithiopsis tubercularis*, but my shell does not correspond with anything that I have seen of this very variable species. It does not seem possible that it can be the young of *C. tricinctum*, though it does not exceed in length $\frac{3}{16}$ths of an inch, for it has seven volutions, which is repugnant to its being the young of any species. The base of our very perfect specimens is quite free from striæ or markings of any kind, and the volutions, which have three nodules, are separated by a deep suture, the two forming the apex being smooth. If the shell should prove distinct from *Greenii* the name *Reevii* might be assigned to it, as the specimen was found and sent to me by Mr. Reeve, of the Norwich Museum.

CHEMNITZIA INTERNODULA? *S. Wood.* *Var.* ligata, 2nd Sup., Tab. II, fig. 11.

CHEMNITZIA INTERNODULA, *S. Wood.* Crag Moll., vol. i, p. 81, tab. x, fig. 6; 1st Sup. Crag Moll., p. 60, for normal form.

Axis $\frac{6}{10}$ths of an inch.

Locality. Fluvio-marine Crag, Bramerton.

The specimen here represented is in the Norwich Museum, and was sent to me by its curator Mr. Reeve. As it seems to differ so materially in form from the numerous specimens and fragments of *internodula* that I have obtained from the Cor. Crag, I have here figured it in juxtaposition with a representation (fig. 12) of one of my specimens from the Cor. Crag of Sutton. It may have been affected, like the *Littorinæ*, &c., by the brackish water, and consequently have much altered its normal form. If it be of the same species I would call it *Chemn. internodula*, var. *ligata;* and the latter might be adopted for its specific designation if the shell should prove to be specifically distinct. The only difference, however, that I can see is that the Norwich Crag shell is much less slender, the internodulation being the same. Mr. Crowfoot has sent me several specimens of this species from the Crag found in the Beccles Waterworks Well, which corresponds with the Fluvio-marine of Bramerton. These, though rather more slender than the variety figured above, are yet nearer to it than to the usual Coralline to Crag form.

CHEMNITZIA SENISTRIATA, *S. Wood.* 2nd Sup., Tab. II, fig. 20.

CHEMNITZIA SENISTRIATA, *S. Wood.* Quart. Journ. Geol. Soc., vol. xxiii, p. 120, 1877.

Spec. Char. Testâ angustâ, subulatâ, elongatâ, apice obtusâ; anfractibus 8—9, *convexiusculis, spiraliter sulcatis, vel striatis; striæ senis, latis, depressis; aperturâ subquadrangulatâ; columellâ rectâ, simplici; labro intus lævigato.*

Axis $\frac{1}{4}$ of an inch.

Locality. Cor. Crag, Sutton.

This is the shell mentioned by me in the 'Crag Moll.,' vol. i, p. 84, as a var. of *similis* with spiral striæ, but no costæ. I now consider it as distinct and figure it under the above name. It approaches a shell called *Scalaria quadristrata* by Dr. Speyer ('Die Conch. der. Casseler. Tert.,' p. 181, tab. xxiv, figs. 7, 8), but the aperture of my shell is of a different form to the one there represented, and it has more numerous striæ than that species. The striæ upon the specimen now figured are six in number, broad and rather flat, separated by a narrow line, and the volutions are very slightly convex.

Chemnitzia similis ('Crag Moll.,' vol. i, p. 84, tab. x, fig. 11) strongly resembles the representations of a shell called *Scalaria?* (*Pyrgiscus*) *Leunisii*, Phil., from the upper oligocene given in Speyer's work, ("Die conch der Casseler Tertiärbildungen." p. 180, tab. xxiv, figs. 10—12), but I have not been able to compare my shell with the original of this. The apex of my shell is obtuse or slightly reversed as in the shell represented by Dr. Speyer, and has ten volutions, with 12—17 upright or slightly sloping costulæ, traversed by six or seven spiral lines. The Crag shell, *similis*, though abundant, is seldom in perfection (the surface being often worn down or decorticated), and it is rather more cylindrical than the German species represented by Dr. Speyer.

Scalaria torulosa, *Brocchi*. 2nd Sup., Tab. II, fig. 13.

Turbo torulosus, *Broc.* Conch. Foss. Subap., vol. ii, p. 377, tab. vii, fig. 4.
Scalaria torulosa, *Hornes.* Vienna Foss., p. 488, taf. xlvi, fig. 13 *a*, *b*.

Length 1 inch.
Breadth 4 lines.
Locality. Cor. Crag ?, Boyton.

A single specimen of this species has been obligingly sent to me by Dr. Reed, and he tells me he obtained it from Mr. Charlesworth, who says it was turned out of the phosphatic nodule workings at the edge of the Butley river in the Parish of Boyton, to which I have already (p. 3, footnote) referred, and its reference to a particular division of the Crag is therefore somewhat uncertain, but unless it be a specimen from the nodule bed itself (in which case it would in all probability be derivative from a formation older than the Coralline Crag), it is to that division rather than the Red that I should refer it. I have little doubt but that it may safely be referred to the fossil called as above by Brocchi; it is also present in the Vienna beds. Our specimen appears to have been a good deal rubbed (which favours its derivative origin), and the fine striæ with which it was originally ornamented are nearly obliterated. I have also received from Mr. R. Bell a fragment of this species, with a notification that it came from the Red Crag of Waldringfield. This fragment is much mutilated and abraded, and evidently of derivative origin.

Scalaria fimbriosa, *S. Wood.* Crag. Moll., vol. i, p. 91, Tab. VIII, fig. 12; 2nd Sup., Tab. III, fig. 17 *a*, *b*.

Locality. Cor. Crag, near Orford.

The specimen now figured presents some differences from that figured in Tab. viii

of the first volume of the 'Crag Mollusca,' in having the varices closer, and a more distinct ridge round the base of the lower whorl, which I have endeavoured to show by fig. 17 *b*, Tab. III. It agrees closely with one, rather larger, sent me by M. Rutot, of Brussels, from Kiel, near Antwerp, a bed which has, until lately, been regarded as miocene, but which M. Vandenbroeck refers to the oldest pliocene,[1] and there can, I think, be no doubt of the identity of the two shells.

SCALARIA GENICULATA ?, *Brocchi*. 2nd Sup., Tab. IV, fig. 11.

TURBO GENICULATUS, *Broc.* Conch. Foss. Subap., p. 659, t. xvi, fig. 1.

Locality. Cor. Crag, Sutton.

A small fragment of a species of the genus *Scalaria* is in my cabinet, which may possibly be referred as above, depending, as I am obliged to do, upon the figure and description by Brocchi. This seems to differ from all other species of the genus in being less strongly or coarsely costulated, and in having the spiral striæ broader and flatter, with a very narrow depression between them.

This is another instance in which I regret my inability to compare my own shell with a veritable specimen of the species to which I have referred it. Brocchi describes his species thus:—"T. subulata, anfractibus subrotundatis, costellis capillaribus, varice ad utrumque latus crassiore." This thickened rib is not visible in my fragment.

TURRITELLA (MESALIA) PFNEPOLARIS, *S. Wood*. 2nd Sup., Tab. II, fig. 14.

TURRITELLA PENEPOLARIS, *S. Wood*. Suppl. to Crag Moll., p. 53, t. iv, fig. 20.

T. Testâ turritâ, elongatâ; apice acutâ? anfractibus 10—12 *convexiusculis striatis; suturâ depressâ; aperturâ subovatâ; columellâ concaviusculâ; labro tenui.*

Axis 1 inch.

Locality. Cor. Crag, Suttton, and Cor. Crag ?, Boyton.

The figures which I have previously been able to give of this shell have been those of fragments only, but I am now enabled to give a figure of the entire shell from one of two specimens sent me by Dr. Reed, which was obtained from the nodule workings at Boyton, but which, therefore, is of uncertain reference so far as its geological position is concerned, and may even be derivative, for it has been considerably abraded. It shows

[1] 'Esquisse Geologique et Paléontologique des Dépots Pliocènes des Environs d'Anvers,' p. 35, Brussels, 1876.

the form of the aperture, which more resembles that of those species from the Lower Tertiaries (such as *Turritella sulcata* and others) which were placed in a new genus proposed by Dr. Gray, 1840, and called *Mesalia*.

The engraver has in the figure shown the specimen in too perfect preservation, for the striations on the upper whorls are, in the specimen itself, obliterated, as are those also along the central portion of the lower whorls, and the aperture also is less perfect than represented.

TURRITELLA TAURINENSIS (?), *Michelotti*. 2nd Sup., Tab. II, fig. 19.

TURRITELLA TAURINENSIS, *Mich.* Etud. Mioc. Inf., p. 84, pl. x, figs. 1, 2.

Locality. Red Crag, Sutton.

This imperfect specimen of some species of the genus *Turritella* has been in my possession for some years. The genus is one in which the determination of a species is most difficult from the great variation which individuals belonging undoubtedly to one species, such as those of *Turritella incrassata*, present, and out of which variation several species have been made. The present specimen seems, however, to differ so much that I think it must be distinct from any of the forms of *incrassata*. There is a difference in the thread-like arrangement of the striæ, and a greater convexity in the volutions, than in either *incrassata* or *terebra*. A shell described by Dr. Speyer, under the name of *Turritella Geinitzii*, Cassel, 'Tert. Conch.,' p. 145, tab. xx, figs. 8—12, is not unlike the one now figured, and I have little doubt that our present specimen is a derivative in the Red Crag from some bed older than the Coralline Crag. Figs. 16 and 17, Tab. II, represent varieties of *T. incrassata*, which may, I think, be referred to *T. acutangulata* and *T. subangulata*, Brocchi.

EULIMA NAUMANNI? *von Könen*. 2nd Sup., Tab. IV, fig. 22.

EULIMA NAUMANNI, *von Könen*. Marine Mittel. Oligoc., t. xi, fig. 19.
— — *Speyer*. Cassel. Tert. Conch., p. 202, taf. xxvi, figs. 12, 13, *a*, *b*.

Axis $\frac{3}{16}$ths of an inch.

Locality. Cor. Crag, Sutton.

A single specimen in my cabinet differs so much from any of the species of *Eulima* known from the Crag that I have referred it provisionally as above, depending upon the representation of the species given in the works of Speyer, and von Könen. So many so-called species in this genus present such trifling differences that before a correct determination can be made it will be necessary closely to compare the specimens themselves,

which, in the present case, I have not been able to do. Our present shell corresponds with the size and form of the figure given by Dr. von Könen, but not quite so much so with the figure by Dr. Speyer, who refers his shell to Dr. von Könen's species. Dr. Speyer's figure, however, shows an obsolete keel (or the vestige of a keel) at the base of the volution, which is not visible in my specimen, nor in von Konen's figure. My specimen seems to have had a very slight curvature at the lower part of the outer lip, but as it is not quite perfect this is obscure. The apex is rather obtuse, and the volutions, of which there are 7—8, are very slightly convex, giving a depression, or great distinctness to the suture.

Eulima Hebe, *Semper*. 2nd Sup., Tab. IV, fig. 18.

Eulima Hebe, *Semper*. Palæont. Unters., s. i, 171 (*fide* Speyer).
— — *Speyer*. Cassil. Tert. Conch., p. 203, taf. xxvii, fig. 2.

Locality. Cor. Crag, Sutton.
Germany: Ober-Oligocene, Nieder-Kaufungen.

The specimen figured is the only one which I have seen, and was found by myself in the Cor. Crag of Sutton. Having now been enabled to compare it with specimens from the German beds, I can assign it as above.

Eulima robusta, *A. Bell*, MS. 2nd Sup., Tab. IV, fig. 17.

Axis, $\frac{1}{2}$ an inch.

Locality. Red Crag, Waldringfield.

This shell, from Dr. Reed's Cabinet, with the above name given to it by Mr. A. Bell, has recently been put into my hands. It somewhat resembles *E. acicula* of Sandberger, figured and described by Dr. Speyer, 'Cass. Tert. Conch.,' p. 205, tab. xxvii, fig. 4, but has apparently fewer and more convex volutions, and is not so elongate and tapering as that species. The apex of our specimen is broken, and the outer lip is nearly straight, like that of *Eul. intermedia*, but it differs from that species in the convexity of the volution. It is doubtless derivative in the Red Crag.

The shell figured in my 1st Supplement (tab. iv, fig. 25) as *E. stenostoma*, Jeff., has since been so injured as to be unrecognisable, so that I am doubtful of its correct assignment, and whether it may not be the shell given above under the name of *E. Hebe*, Semper.

On the other hand, I have specimens from the Coralline Crag of *Eulima* differing

from *E. subulata* in the possession of a curved lip, which appears to be the only distinction from that shell upon which d'Orbigny's species of *subula* is founded. With this, and omitting, for the reason just given, *stenostoma* from the category, the following ten species of what I refer to the genus *Eulima*, with the exception of the derived *robusta*, have formed part of the Crag fauna, one of them, the doubtful *similis*, belonging to the newer or Red division only.

It must be confessed that some of these species are separated upon distinctions such as in more variable genera are considered only of varietal importance. Continental conchologists seem to consider the form of the outer lip as a good auxiliary character for separation, but I am unable to say if this be one on which a safe reliance can be placed. Shells of this genus are of a porcellanous structure and opaque, the lines of increase being invisible.

1. Eulima polita, *Linn.* Crag Moll., vol. i, p. 96, tab. xix, fig. 1 *b*. Curved outer lip.
2. — intermedia, *Cantraine*. Crag Moll., vol. i, p. 96, tab. xix, fig. 1 *a*. Lip nearly straight.
3. — subulata, *Donovan*. Crag Moll., vol. i, p. 96, tab. xix, fig. 3. Straight outer lip.
4. — subula, *D'Orbigny*. Prodrom., iii, p. 34, No. 478. Curved outer lip.
5. — bilineata, *Alder*. Sup. Crag Moll., p. 66. Spirally coloured.
6. — similis ?, *D'Orb.* Sup., Crag Moll., p. 65, tab. vii, fig. 6. Spire inflected.
7. — glabella, *S. Wood*. Crag Moll., p. 98, tab. xix, fig. 2. Apex obtuse.
8. — Hebe, *Semper*. 2nd Sup., Tab. IV, fig. 18. Elongated aperture.
9. — Naumanni ?, *von Könen*. 2nd Sup., Tab. IV, fig. 22.
10. — robusta, *A. Bell*. 2nd Sup., Tab. IV, fig. 17. Convex volution.

Rissoa costulata, *Alder*. 2nd Sup., Tab. IV, fig. 23.

Rissoa costulata, *Alder*. Mag. Nat. Hist., xiii, p. 324, pl. viii, figs. 8, 9.
— — *Forb. and Hanl.* Brit. Moll., vol. iii, p. 103, pl. lxxvii, figs. 4, 5.
— — *Jeffreys*. Brit. Conch., vol. iv, p. 35, pl. lxviii, fig. 1.

Locality. Cor. Crag, Sutton.

A single specimen has very recently come into my hands from Dr. Reed, with the above-named locality given to it by Mr. A. Bell. This resembles in form *Rissoa crassistriata* of 'Crag Moll.,' vol. i, tab. xi, fig. 13, but that shell has large and coarse spiral striæ, of which the present species is destitute.

Rissoa parva ?, *Da Costa*. 2nd Sup., Tab. IV, fig. 21.

Locality. Cor. Crag, Sutton.

The specimen figured is from my own cabinet, and was found by myself. It appears to answer to this species, though from being unique and imperfect, I give it with doubt.

Rissoa reticulata, *Mont.* 2nd Sup., Tab. IV, fig. 19.

A specimen with this name has been sent to me by Dr. Reed, which seems to correspond with the recent British shell to which I have, as above referred, it. The shell so called in 'Crag Mol.,' vol. i, p. 163, tab. i, fig. 5, has been the subject of a criticism not easily to be understood (see 1st Suppt., p. 73). I have therefore had the present specimen figured, which is a more elongated form.

Hydrobia obtusa, *Sandberger.* 2nd Sup., Tab. IV, fig. 7.

Littorinella obtusa, *Sandb.* Conch. de Mainz Tertiarb., s. 81, taf. 6, fig. 8 *a—c.*

Length 1 line.

Locality. Fluviomarine Crag, Bramerton.

Several specimens of this little shell have been sent to me by Mr. Jas. Reeve, who tells me that he found them at Bramerton, and was doubtful about their correct assignment. The one figured is the longest of the series, and seems to approach very close to the figure of the shell given by Dr. Speyer from the middle oligocene of Germany, under the name of *Bithinia obtusa,* Sandberger; and as the specimens show the same thickened lip as does his figure, I have ventured to identify them with it. As the specimens are in good condition, and the allied species *subumbilicata, thermalis,* and *ventrosa,* which are abundant and in very perfect condition at Bramerton, are also figured by Dr. Speyer (under the name *B. acuta,* Drap.) from the same middle oligocene beds, I am disposed to regard the species now under description as having lived in the waters of the Crag Period equally with *subumbilicata;* and not to be of the derivative origin of the shells described in the postscript.

Natica (Amauropsis) japonica ?, *A. Adams,* M.S. 2nd Sup., Tab. III, fig. 11.

Axis $\frac{1}{4}$ of an inch.

Locality. Red Crag, Butley.

A small specimen is among the shells sent to me by Dr. Reed, with the above name attached (by, I believe, Mr. A. Bell, who obtained it from Butley).

It is in good preservation and I have had it here figured, but whether it be the shell above

named I must leave for further observation and more specimens to determine. It much resembles a small form of *Natica helicoides* (*Islandica*, Gmel.), 'Crag Moll.,' vol. i, p. 145, tab. xvi, fig. 3, and may possibly be the young of that shell, though it seems to be more elongated, and to possess a more elevated spire and more pointed umbo; the present specimen is quite free from striæ of any kind, and it does not appear to have lost any of its outer coating, which is so common in specimens of *Naticæ* from that locality, and this is perhaps in favour of its being distinct. I have not been able to see the living shell to which Mr. Bell has referred it, which, on the label appended to our present specimen, is called "undescribed." The volutions in this specimen are convex, and between them is a deep and depressed suture, like that upon *helicoides*, but our present shell has a very distinct umbilicus. Mr. Bell tells me he has seen the young of *N. helicoides*, and that our present shell differs from it. I have put a mark of doubt against the present name, as I have not much confidence in the above assignment.

NATICA GROENLANDICA ?, *Beck.*, var. *declivis*. 2nd Sup., Tab. III, fig. 12 *a—b*; Crag Moll., vol. i, p. 146, Tab. XII, fig. 5; 1st Sup., p. 75.

Axis $\frac{7}{8}$ths of an inch nearly.

Locality. Red Crag, Butley.

The shell now figured differs so materially from all the Crag *Naticæ* that I have been at a loss to what it should be referred. Its elevated spire almost brings it into what has been generically called *Amauropsis*, but as I believe it to be a true *Natica* I have preferred to give it here simply as a very abnormal form of some known species of that genus; and as *N. Groenlandica* seems to answer to it in respect of the more reliable characteristics upon which the species of *Natica* have been separated, and is withal a variable species, it is to this that I provisionally assign it as a variety (*declivis*). I am reluctant to assign new specific names on the evidence of a solitary specimen where the distinction of it from any other known form is not clear, but if further specimens of this shell should be found, then I think it might be regarded as a new species under the name *declivis*.

NATICA TRISERIATA ? *Say*. 2nd Sup., Tab. III, fig. 14, *a—b*.

NATICA TRISERIATA, *Say*. Journ. Acad. Nat. Sci., v. 211 (*fide* Gould).
— — *Gould*. Invert. Massachusetts, p. 233, fig. 165.

Axis 1 inch.

Locality. Red Crag, Butley.

The specimen figured seems to be intermediate between *Natica sordida* and *Natica Alderi*, approaching rather nearer to the latter than the former, but to neither does it strictly accord, having the form and nearly the size of *sordida*, but without its depression upon the upper portion of the volution. It is also rather more elongated than either, while the left lip is more extended than in *Alderi*, but rather less so than *N. sordida*. The shell is strong and nearly ovate, the contour showing but very little depression between the volutions, which slopes from the small and pointed apex. The exterior is smooth with simple lines of growth. As the specimens maintaining these characters are not rare I have ventured to refer them as above, though they bear a resemblance to *Natica hemiclausa*, a shell very abundant in the older part of the Red Crag at Walton Naze, but this latter has the umbilicus covered by the left lip in specimens that are full grown.

Naticæ are extremely abundant in the Butley bed, in association with the various peculiar and northern species of mollusca, which distinguish that newer portion of the Red Crag from the older or Walton portion, and their generally decorticated condition, in which the specimens which I refer to *triseriata* participate, increases the difficulties which attach to their specific separation.

I have not the recent species for comparison, and in making my reference to it my dependence is upon the figure and description given by Gould. The coloured markings which induced that author to give to it its name have disappeared in the Crag fossil, if they ever were present. There is also a resemblance between our fossil, and *Natica immaculata*, Totten, but this Mr. Jeffreys refers to *N. Alderi*, to which species I think the present fossil does not belong.

In ‘ Crag Moll.,’ vol. i, p. 144, I said, when speaking of *Natica varians*, “ It appears to be quite distinct from *Natica hemiclausa*, and it agrees in most of its characters with *N. varians* from Touraine.” I am still of the same opinion. In Mr. Prestwich’s List, p. 144, *N. varians* of the Cor. Crag is referred as a variety to *N. cirriformis*, but *N. cirriformis* is *there* referred to *N. sordida*. In Mr. A. Bell’s List of the Lower English Crag, *N. varians* of the Crag is considered as *N. helicina*, Broc. The same shell is by M. Nyst figured as *Natica hemiclausa*, Sow. These conflicting opinions afford a proof of the perplexity in which those who study fossil mollusca become involved when occupied with this genus.

I have in Tab. III, fig. 7 *a—b*, given the representation of another specimen of this genus from the Coralline Crag near Orford, which is in Mr. Cavell’s collection. This seems to differ materially from the shell which I have figured as *N. helicina* from the Red Crag of Walton Naze (‘ Sup. Crag Moll.,’ p. 74, fig. 8 *a*, *b*), as it possesses a large and deep umbilicus, and although the front of the shell shows a depression at the suture, there is remaining a small portion of shelly matter, which if continuous would cover this deep suture entirely, and indicate that it possessed this covering feature, which is wanting in *N. helicina*.

Being a solitary specimen and surrounded by this uncertainty I have not ventured to assign it as a new species, preferring to give it as a variety, *heliciformis*, of *N. helicina;* but should more specimens occur maintaining its characters that varietal name might be assigned to it specifically.

In Tab. IV, fig. 12, of my first Supplement, is represented a specimen under the name of *N. proxima*, S. Wood, and at p. 74 of the same Supplement, the shell so represented is referred to the species figured in Tab. XVI of my original work under that name. As, however, the specimen in question does not show the depression on the upper part of the volution, and seems to be identical with the shell above given as *N. triseriata*, this reference was, I now consider, erroneous; and the figure should be regarded as one of the last-named species.

AMAURA HESTERNA, *S. Wood.* Figured in the margin.

Axis. $\frac{1}{4}$ of an inch.

Locality. Crag, Boyton.

Spec. Char. Testâ turritâ, elongato-conoideâ, nitidâ, glabrâ; apice obtusâ et depressâ; anfractibus convexiusculis 5—6*; suturis distinctis; aperturâ brevi pyriformi: labro acuto simplici.*

Mr. Robert Bell has sent me a specimen, but without a name, which he says came from Boyton, and which appears to belong to the same genus as the specimen figured in my first Supplement under the name of *Amaura candida*, Tab. I, fig. 3, from the Red Crag of Butley, and of which a very perfect specimen was also obtained by Mr. Crowfoot from the locality of Boyton. This latter specimen, however, was stained with the Red Crag colour as much as was the Butley specimen, and undoubtedly belongs to the Red Crag. The specimen I am now describing, however, though evidently of the same genus, is not only specifically different from *candida*, but is unstained with any red colour, for it is polished and nearly colourless. It has the two apical volutions shallower and more depressed comparatively to the others, the suture distinct and somewhat deep, the aperture elongately ovate, terminating acutely at the body of the volution, the outer lip sharp and simple, with a small but distinct umbilicus, and the body whorl occupies more than half of the entire shell.

Amaura hesterna, *S. Wood*, enlarged $\frac{4}{1}$.

This and *candida* are the only species of the genus at present known to me. Their generic character is particularly indicated by the uppermost whorls that succeed the apex being unlike those which follow them, for instead of maintaining the proportions with which the shell commences to grow, the whorls increase in depth far beyond the proportions due to the increasing size of the animal, so that the angle of volution becomes greatly diminished. In fact, the Mollusc appears to begin life under the form of *Natica*,

and, after the growth of two whorls, to change its form so as to produce a shell quite unlike the oblate form of *Natica*, and of a more cylindrical shape. Our present shell is much more tapering than *candida*, and it possesses also one more whorl than the Red Crag specimens of that species, though it has only half their linear dimensions. It therefore seems to be a full-grown shell.

ADEORBIS ? NATICOIDES, *S. Wood.* 2nd Sup., Tab. III, fig. 13 *a*, *b*.

Diameter, $\frac{1}{10}$th of an inch.

Locality. Cor. Crag, Sutton.

A small shell has been in my hands for many years, found by myself in the Cor. Crag of Sutton. This has always much perplexed me, and it remained in my cabinet unfigured and undescribed from the idea that it might be the young or embryo condition of some larger species, and in the hope that I might obtain something further to assist in its correct determination. Not having succeeded in this, I now figure the specimen as above. I have a large number of very small specimens of several species of *Natica*, and have broken up many of them with the expectation that I might produce something that would show a keel round the umbilicus similar to the one in my present specimen, but without success. There is a large umbilicus in some species of *Natica*, but in none can I find any ridge around this great opening such as the shell now figured presents. Two very anomalous shells, having large umbilical openings surrounded by a keel, have been figured by the late M. Deshayes, viz. *Lacuna mirabilis*. 'An. du Bas. de Par.,' vol. ii, p. 372, Pl. XVIII, figs. 1—4, and *Sigaretus problematicus*, vol. iii, p. 90, Pl. LXIV, figs. 7—9; but neither of these correspond to our present specimen. There is also the living British species, *Lacuna pallidula*, which possesses a somewhat similar keel round an open umbilicus; but our shell has a distinct ridge or keel *within* the umbilical aperture, of which no species of *Lacuna* that I have examined shows any trace.

Delphinula trigonostoma, 'Bast. Bord. foss.,' p. 28, Pl. IV, fig. 10 (which I had given as a synonym to *Adeorbis subcarinata*, but I believe erroneously), is perhaps the nearest approach to my shell. I feel that the reference of the shell is very doubtful, but I give it to draw the attention of collectors.

TROCHUS ZIZIPHINUS, *Linn.* 2nd Sup., Tab. IV, fig. 20; Crag Moll., vol. i, p. 124, Tab. XIII, fig 9; 1st Sup., p. 81.

Dimensions. *Height*, $\frac{1}{13}$th inch.
Breadth, $\frac{11}{16}$th inch.

Locality. Cor. Crag, Sutton.

The present shell is from the collection of Mr. Canham, who tells me he procured it from the lower portion of the Cor. Crag at Sutton, and I have figured it in consequence of its unusual size. This shell was originally figured in Min. Conch under the name of *T. lævigatus*, and figured under that name by Nyst from the Belgian beds. In my catalogue (1842) I called it *pseudo-ziziphinus;* from its resemblance to the living *ziziphinus*, and in the first vol. of Crag Moll. gave it as identical with that shell. It appears to be identical in ornament (though not in form, being less tapering), with a specimen from the Sicilian beds in my cabinet. This is probably the same as the shell living in the Mediterranean called *conulus*. I have many Crag specimens, smaller than the one figured, in which the exterior with its ornamentation is in perfection; and this so agrees with that in *conulus*, that if our Crag shell called *ziziphinus* be only one of the living varieties of that species, I think *conulus* and *ziziphinus* should be united.

ASSIMINIA GRAYANA? *Leach.* 2nd Sup., Tab. III, fig. 18 *a*, *b*.

ASSIMINIA GRAYANA, *Leach.* Fleming's Brit. Anim., p. 275.
— — *Forb. & Hanl.* Brit. Mollusca, vol. iii, p. 70, pl. lxxi, figs. 3, 4.
— — *Jeffreys.* Brit. Conch., vol. v, p. 99.

Locality. Fluvio-marine Crag, Bramerton.

Two specimens have been sent to me by Mr. J. Reeve as from the "*Scrobicularia* bed at Bramerton,"[1] having been thought by him to be something different from *Hydrobia ventrosa*. One of these two I have here had represented, and I have referred it with some doubt as above, as it does not strictly accord with the living shell, which is obscurely angulated at the base of the last volution, like the shell of *Hydrobia ulvæ*, whereas in our present specimens the base is rounded. It differs materially from any specimen of *ventrosa* that I have seen, and has not the depressed or deep suture of *Bythinia Leachii*. In form it seems intermediate between *B. tentaculata* and *H. ventrosa*.

The shells at Bramerton being not unfrequently so distorted as to be scarcely recognisable for the species, or even genus, to which they belong, it is possible that the specimens in question are cases of this kind, so that I make the present reference with all reserve.

[1] This Scrobicularia bed at Bramerton appears to intervene between the few feet of specially Fluvio-marine Crag ($4\overline{4}$ of sect. xvi of the Introduction to my first 'Supplement') which rests on the chalk and the Chillesford bed (5′ of that section), thus answering exactly to the Scrobicularia beds at Butley, (4‴ of sect. xvii of the same Introduction) to which the fourth column of the synoptical list refers.

Valvata cristata, *Müller*. 2nd Sup., Tab. IV, fig. 8 *a*, *b*.

Valvata cristata, *Müll.* Hist. Verm., pt. ii, p. 198.

Locality. Fluvio-marine Crag, Bramerton.

This shell is abundant in the Freshwater deposits of Stutton, Grays, and Clacton, but I have only met with the one now figured from the Fluvio-marine Crag.

Valvata piscinalis. 2nd Sup., Tab. IV, fig. 9.

Locality. Fluvio-marine Crag, Bramerton.

This is also very abundant in the same Freshwater deposits, but it is very rare in the Fluvio-marine Crag; it so closely resembles *Margarita helicina* that it is very difficult to distinguish the difference, and scarcely possible, except with perfect specimens; and I am doubtful whether a specimen found by Mr. Harmer at March, given by me at p. 121 of Vol. XXIII of the 'Quart. Journ. Geol. Soc.,' as *Trochus helicinus*, may not be merely *Valvata piscinalis*, since Freshwater shells occasionally occur in the March gravel.

The figure previously given of *V. piscinalis*, 'Crag Moll.,' Tab. XII, fig. 3, represents the depressed form, and I have given the more elevated one, which, when first discovered, was considered as a distinct species, and called *antiqua*.

The reference of *Margarita helicina* to the Coralline Crag made in my Catalogue of 1842 was an error.

Limnæa auricularia, *Linné*. 2nd Sup., Tab. IV, fig. 3 *a*.

Helix auricularia, *Linn.* Syst. Nat., edit. 12, p. 1249.
Limnæa — *Jeffreys*. Brit. Conch., vol. i, p. 108, pl. vii, fig. 4.
Limnæus auricularius, var. acutus, *Forb. & Hanl.* Vol. iv, p. 171, pl. cxxiii, fig. 2.

Locality. Fluvio-marine Crag, Bramerton.

A single specimen, as above represented, has been sent to me by Mr. Reeve, and it is the first instance that I have met with of this species having been found in the Crag. It is, however, present in most of our newer Pliocene Freshwater beds, as may be seen in my List, 'Crag Moll.,' vol. ii, p. 307. Dr. Jeffreys gives three varieties to this species, our shell agreeing best with the one he first gave as distinct (*Limnæus acutus* in 'Linn. Trans.,' xvi, p. 373), but which he afterwards reduced to a variety. Our fig. 3 *b* was made from a recent specimen by mistake.

LIMNÆA PALUSTRIS, *Müller*. 2nd Sup., Tab. IV, fig. 2 *a*, *b*.

BUCCINUM PALUSTRE, *Müll.* Verm. Tert. et Fluv., vol. ii, p. 131.

Locality. Fluvio-marine Crag, Bramerton.

The shell figured and described in 'Crag. Moll.,' vol. i, p. 7, Tab. I, fig. 9, as *L. palustris* is, I think, there erroneously referred, as it more resembles the American species or variety called *elodes*, to which I would now refer it. I have received from Mr. Reeve a specimen, of which the one above referred to is a representation, and which, I think, is the true form of *L. palustris*.

LIMNÆA PEREGRA, *Müller*. 2nd Sup., Tab. IV, fig. 4.

BUCCINUM PEREGRUM, *Müll.* Verm. Hist., pt. xi, p. 130.

Locality. Fluvio-marine Crag, Bramerton.

The shell now figured is the true form of the common variety of this species. The one previously figured in 'Crag Moll.,' Tab. I, fig. 7, resembles the northern form called *L. Pingelii* by Möller, to which I will refer it. Fig. 8 of Tab. I of 'Crag Moll.,' there called *L. truncatula* (?), corresponds with *L. Holbollii*, Möller, and I have not seen the true form of *truncatula* from any East Anglian bed.

PUPA EDENTULA, *Draparnaud*. 2nd Sup., Tab. IV, fig. 6.

PUPA EDENTULA, *Drap.* Hist. Moll., p. 52, pl. iii, figs. 28, 29.

Locality. Fluvio-marine Crag, Bramerton.

This has been obtained by Mr. Reeve, and he tells me it is from the "*Scrobicularia* bed" at that locality.[1] The generic name of *Vertigo* is now given to this shell by some authors in consequence, it is said, of a difference in the animal, *Vertigo* having only two tentacles, while that of *Pupa* has four; but there is nothing in the shell to denote a generic difference, and I have therefore retained its original name. Our present shell is not rare in the newer Pliocene Freshwater beds, but it has not been hitherto given as a Crag shell, so far as I am aware.

[1] See note, p. 35.

MELAMPUS FUSIFORMIS, *S. Wood*, var. ELONGATUS. 2nd Sup., Tab. III, fig. 15; Crag Moll., vol. i, p. 12, Tab. I, fig. 14; and 1st Sup., p. 3, Tab. I, fig. 1.

Locality. Red Crag, Waldringfield.

The above specimen was obtained by Mr. Canham, and is perfect, except a slight fracture in the back, which, however, is no injury to the shape of the shell. It is more elongated than any form of the genus that I am acquainted with, but, unfortunately, the artist has not represented this character sufficiently in the present figure, which can scarcely be distinguished from the original *fusiformis*.

BULIMUS LUBRICUS, *Müller*. 2nd Sup., Tab. IV, fig. 10; 1st Sup., p. 187.

HELIX LUBRICA, *Müll.* Hist. Verm., pt. xi, p. 104.
ZUA LUBRICA, *Forb. & Hanl.* Brit. Moll., vol. iv, p. 125, pl. cxxv, fig. 8.
COCHLICOPA LUBRICA, *Jeff.* Brit. Conch., vol. i, p. 292, pl. xviii, fig. 2.

Locality. Red Crag, Butley.

The specimen figured is that referred to in my first 'Supplement' as found by Mr. Canham, in the Crag of Butley, and although it is not uncommon in the Freshwater deposits of Stutton, Clacton, Grays, and Copford, it is the first and only one that I have seen from the Crag; I have therefore had it figured. This shell has received several generic names, but the above having been previously used in my list of the Land and Freshwater shells in my second volume of the 'Crag Moll.,' I have not thought it necessary to alter it here.

POSTSCRIPT.

DURING the progress of the foregoing through the press Mr. Jas. Reeve, of the Norwich Museum, was good enough to send me a quantity of small shells, which he had extracted from the sand of the Bramerton Crag Pit. These consisted for the most part of specimens of species already figured and described, but among them were two or three which appear to me to be quite new to the Crag, if not, indeed, undescribed from any formation. These specimens are all more or less worn and imperfect, a character which is not usual with the specimens of species belonging to any horizon of the Crag in Norfolk; and I feel little doubt that they are not shells which lived in the Crag waters,

but are derivatives from some other formation. As they approach species figured in Dr. Speyer's work from the Oligocene of Cassel, in Germany, nearer than they do to any others that I can find figured and described, I suspect that they have been introduced from some Upper Eocene or Oligocene formation in North-Eastern Norfolk, through which a stream flowed which discharged into the estuary of the Fluvio-marine Crag. The probability of such a thing is strengthened by the circumstance that the chalk disappears below the water-line of the country immediately east of the Bramerton Crag Pit, and by the Lower Eocene having been pierced at Yarmouth and found to extend to a depth of 526 feet below the sea level.[1]

The specimens in question comprise—

1. Cerithium derivatum, *S. Wood.* Figured in margin.

Locality. Fluvio-marine Crag, Bramerton.

Two specimens of this species were among the shells sent by Mr. Reeve. One of these was so much worn and mutilated as to be recognisable with great difficulty, but the other, which is that represented in the zincograph, is in tolerable condition; for though it has lost its apex, that is a thing not unfrequent with fossils of this genus, even where no suspicion of derivation attaches to them, and the surface is but little worn. It resembles the representation given by Dr. Speyer of *Cerithium Descoudresi,* from the Upper Oligocene, 'Cassel Tert. Conch.,' Taf. xx, fig. 2 *a, b;* but his figure shows six distinct transverse or spiral lines, whereas the Bramerton specimen shows but four on the lower, and not so many on the upper whorls. With that distinction I have been unable to refer the specimen to Dr. Speyer's species, but as the number of transverse lines in this genus is not a constant character, it may, nevertheless, belong to it, and further specimens would determine that question. I have accordingly assigned to it provisionally the above name in order to distinguish its derivative origin. The specimens will be preserved in the Norwich Museum.

Cerithium derivatum, *S. Wood,* enlarged 2/1.

2. Odostomia? derivata, *S. Wood.* Figured in margin.

Locality. Fluvio-marine Crag, Bramerton.

Several specimens of this shell were among the quantity already mentioned as sent

[1] Prestwich, in 'Quarterly Journal of the Geol. Soc.,' vol. xvi, p. 450.

me by Mr. Reeve ; but all of them were in a more or less mutilated condition. One of the best preserved of them is represented in the accompanying zincograph.

Odostomia derivata, *S. Wood*, enlarged $\frac{12}{1}$.

The shell much resembles the figure of *Actæon lævisulcatus* of Sandberger (Nos. 4 and 5 of Taf. xxxiii of Dr. Speyer's 'Cassel Tert. Conch.'), a species of the Upper and Middle Oligocene of Germany; but as neither the apex nor the mouth of any of the Bramerton specimens are perfect, I do not feel sufficient confidence in their identity to refer them to Sandberger's species, and have, therefore, given them under the above name provisionally. The shading in the figure being effected by coarse lines gives the erroneous idea of the shell being covered with fine vertical lines. It, however, possesses only the strong horizontal or spiral striæ shown in the figure.

Besides the above there was a single specimen of an *Odostomia*, which I am unable to refer to any Crag species or to any living British form ; but it is too much worn for me to venture to describe it as a new species. It is about an eighth of an inch in length, and in its present state is free from striæ. It is probably, like the foregoing, a derivative from some older formation. There were also among the specimens fragments of the hinge portion of a small bivalve resembling the figure of *Siliquaria parva*, Speyer ('Ober. Oligocan Tert. Detmold,' p. 33, Taf. iv, fig. 2), but they are too imperfect for correct recognition. There was also among them an imperfect specimen of a minute *Actæon*, which, I think, may be perhaps *A. Philippii*, Koch and Wiechmann (Die oberoligoc. Fau. des Sternberger Gesteins in Meckl.,' Abth. s. 7, Taf. i, fig. 3 *a—c*, represented by Speyer in Taf. xxxiv, fig. 1—3 of his work on the 'Cassel Tertiaries.') It resembles that species in form; and possessing four complete whorls, though only one eighth of an inch in length, it can hardly be the young of either of the Crag species *Noæ* and *tornatilis*. As, however, I could not under a magnifyer detect the peculiar pitted marks which separate the striations in *A. Phillippii*, I have not ventured so to assign it. Among the specimens there was also one of *Rissoa proxima*, Alder, which, though it has lost the upper whorls, is otherwise well preserved, and on the authority of it I have introduced that name into the Fluvio-marine Crag column of the synoptical list. These specimens also will be preserved in the Norwich Museum.

BIVALVIA.

Anomia striata, *S. Wood.* 2nd Sup., Tab. VI, fig. 3 *a—f;* Crag Moll., vol ii, p. 11, Tab. II, fig. 3; 1st Sup., p. 100.

Diameter. $1\frac{7}{8}$ths of an inch.

Locality. Cor. Crag, Sutton and near Orford.

In my figure and description of this shell in the 'Crag. Moll.,' above referred to, the exterior only is represented. I now give, therefore, one of the interior of a specimen of similar magnitude, and also a separate fig. (3 *c*), representing the thickened portion of the lower valve, which resembles what I erroneously figured in 'Crag. Moll.' (vol. ii, Tab. XXXI, fig. 24), as possibly the internal shell of *Aplysia.* The lower valve of *Anomia* is very thin, except the ridge, which is represented in fig. 3 *d,* which, therefore, is the only part of this valve usually found; but fig. 3 *e* represents a perfect specimen of this valve, showing the opening for the byssus close to the connecting ligament.

Fig 3 *f* represents a small specimen of the upper valve from the Coralline Crag of Sutton, which shows that the shell in its young condition is perfectly free from striæ, these appearing when it is a little further advanced in life. This is the only specimen out of many hundreds that I have obtained from the Cor. Crag in which this feature is shown.

Ostrea ungulata, *Nyst.* 2nd Sup., Tab. V, fig. 7 *a, b;* Crag Moll., vol. ii, Tab. II, fig. 1 *a.*

Ostrea ungulata, *Nyst.*, var. A. Coq. Foss. Belg., pl. xxxiv, fig. 1.

Locality. Cor. Crag, Ramsholt.

I have here given another figure of the *Ostrea* occurring in the Coralline Crag, which was in the 'Crag Mollusca' referred by me to *edulis*, and of which a specimen with the two valves united is represented in fig. 1 *a* of Tab II of vol. ii of that work. I

am now inclined to think that this form is so far distinct from the common *edulis* that it should be separated from it. The *O. edulis* of our coasts has the lower valve always more or less covered with imbricated radiations, of which the Cor. Crag shell is destitute, or on which, at least, they are obsolete or nearly invisible. The *common* form of our edible Oyster has not come under my observation, either from the Coralline or from the Red Crag. Figs. *a* and 2 *b* of Tab. II, 'Crag. Moll.,' may possibly be the immature state of *O. princeps*. Our edible Oyster is described in 'Brit. Conch.,' vol. ii, p. 38, as having the "hinge-line narrow and nearly straight," "lateral edges (especially of the flat valve) finely crenulated or notched on the upper part;" but the Cor. Crag shell is destitute of these, and the depression left by the connector is greatly incurved; I have, in consequence, had the outside of the lower valve, as well as the place of the connector figured.

The Cor. Crag shell is very thick and ponderous; and in that respect it resembles the more southern form of *edulis*, which Lamark described as a species under the name of *Ostrea hippopus*. It, however, corresponds better with the Oyster from the Antwerp beds, which is figured by M. Nyst under the name *ungulata*, var. A.

M. Nyst says of this shell (p. 326 of his work), "La var. A est plus bombée. Les sillons longitudinaux ont entièrement disparu sur les deux valves," but in his figure he has represented these "sillons" (radiations) obsolete or obscure, like they are on our Cor. Crag. shell. He gives the localities of *O. ungulata* as Anvers and Bognor, but does not specify the special locality for var A. The form in his pl. xxiv, fig. 1, is, however, probably *O. Bellovacina* from Bognor, while var. A is presumably from Anvers; and on that assumption I have referred our Crag. shell to it, for it is certainly not the Eocene *Bellovacina*.

In the ever recurring difficulty as to whether shells in the Red Crag belong to that formation, or are only derivative in it, it is impossible to say whether this shell, of which specimens have occurred in the Red Crag, belongs to the age of that Crag or not; but I have not met with the true form of the British *O. edulis* in the Red Crag.

I do not think now that the shell figured in my first Supplement, Tab. VIII, as *Ostrea plicatula* is the same as the shell here figured as *ungulata*.

MYTILUS EDULIS, var. GALLOPROVINCIALIS. 2nd Sup., Tab. VI, fig. 9.

MYTILUS GALLOPROVINCIALIS, *Lam.* An. Sans. Vert., t. vii, p. 46.
— — *Phil.* Moll. Sic., vol. ii, p. 53, t. vi, figs. 12, 13.

Locality. Red Crag, Sutton.

The specimen of this peculiar form, above figured, has been obtained by Mr. Edward Moore, of Woodbridge, from the Red Crag as above.

MYTILUS EDULIS, var. UNGULATUS. 2nd Sup., Tab. VI, fig. 9 *b*.

MYTILUS UNGULATUS, *Linn.* Syst. Nat., p. 1137.

Locality. Cor. Crag? Boyton.

The present figure, *ungulatus*, represents a specimen obtained by Mr. Charlesworth, now in the cabinet of Dr. Reed; this is said to be from Boyton, and from the colour of the specimen, it most probably came from the Lower or Cor. Crag of that locality. These two very different forms of this genus, *galloprovincialis*, and *ungulatus*, are now generally admitted to be only variations of our common edible mussel, and I have introduced them to show that they lived in the Crag Sea. They were both figured by Dr. Jeffreys in the 'Mag. Nat. Hist.' for 1859, and at p. 10, *ungulatus* is there described as an "unquestionably distinct species;" but in his later work, the Brit. Conch., they are considered as varieties of *edulis*, in which opinion I coincide. Fig. 20, Tab. II, of 'Woodward's Geol. of Norfolk' is another form of this variable species.

PECTUNCULUS PILOSUS, var. INSUBRICUS. 2nd Sup., Tab. VI, fig. 4 *a*, *b*; Crag. Moll., vol ii, Tab. IX, fig. 1 *d*.

ARCA INSUBRICA, *Broc.* Conch. Foss., sub. ap., p. 492, tav. xi, fig. 10 *a*, *b*.

Locality. Cor. Crag, Sutton and Ramsholt.

When figuring the shells of this genus in 'Crag Mol., vol. ii, tab. ix, I gave a representation (fig. 1 *d*) of what I considered as an elongated variety of *P. glycimeris*, but this has since been given as a distinct species from the Crag, by Mr. A. Bell, as *P. insubricus*. I have therefore now given a figure of its interior, and I am unable to perceive any differences in this shell which justifies its separation from the general thick solid form which has been called *pilosus*, beyond its slightly more elongated form, and this may be connected with the more laterally extended form, common to *pilosus*, by individuals partaking more or less of this elongated character. The recent shell called *P. violacescens*, presents precisely the same form, with hinge and denticles the same. Fig. 5 *a* of Tab. IV is one of the laterally extended forms of *P. glycimeris*, from the Coralline Crag of Sutton, obtained by myself. Fig. 5 *b* is that of a specimen of my own from the Cor. Crag of Sutton, which seems to agree with that figured by Brocchi, 'Conch. Fos. Sub-Ap,' p. 483, Tab. II, fig. 8, under the name of *nummarius*. Fig. 4 *b* represents the inner lining of one of my specimens which separated itself; and as it corresponds with a figure given by Phillippi, 'En. Moll. Sic.,' Vol. II, Tab. XVIII, fig. 10 *a*, *b*, I thought it best to have it here figured.

NUCULA TURGENS, *S. Wood.* 2nd Sup., Tab. V, fig. 6 *a*, *b*.

Spec. Char. N. testâ ovato-rotundatâ, ventricosâ, tumidâ, partim lævigatâ et partim concentricè costulatâ; margine dorsali et ventrali convexiusculâ; margine intus denticulatâ.

Diameter $\frac{3}{8}$ths of an inch.

Locality. Red Crag, Waldringfield.

A single specimen of the genus *Nucula* is among Dr. Reed's specimens, kindly sent to me for examination, which I have here had represented; it has attached to it the name of *N. nucleus?* var. I think, however, it cannot be referred to that species, which is much less inflated, and comparatively longer. The two valves are closely united, and cannot be separated without endangering the integrity of the specimen. The shell to which it seems to approach the nearest, from its tumidity, is *N. sphenoides*, Edwards, an Eocene species, but that shell differs in shape, being more angular and elongated. Our shell may be described as small, roundedly triangular, and very tumid, margin crenulated (the margins, though the valves are adherent, disclosing this). The exterior, which has been much rubbed, is smooth on the part nearest the umbo, but deeply ridged on the part nearest the margin, and these ridges do not appear to be the result of decomposition. Mr. Hancock has figured and described a shell under the name of *N. inflata*, 'Ann. and Mag. Nat. Hist.,' 1846, p. 333, pl. v, figs. 13, 14, and this, Mr. Hanley says, in his 'Monog. of the Nuculidæ' (p. 34, figs. 115, 116) is the same as *N. tenuis*, Möller (as he has determined from the examination of his specimen), but as this latter has a smooth margin and is more transverse than our present shell I am not able to refer the latter to it, and have therefore given to it provisionally a new name.

It may not improbably be a derivative specimen.

ARCA TETRAGONA, *Poli.* 2nd Sup., Tab. VI, fig. 8 *a*, *b*; Crag. Moll., vol. ii, p. 76, Tab. X, fig. 1; 1st Sup. to do., p. 116.

Locality. Cor. Crag, Sutton.

The specimen 8 *b* now figured is given merely because it is that upon which the name of *Arca nodulosa*, Müll., was introduced by Mr. A. Bell, into his list of Crag shells in the 'Proc. of the Geological Association,' vol. ii. It is now in the cabinet of Dr. Reed, and has been sent to me by that gentleman with the proposed name of *Arca puella*, A. Bell, attached. I have had a small specimen of my own finding here also represented (fig. 8 *a* of Tab. VI), which is very like it, and both, in my opinion, are specimens of *A. tetragona*, with coarser ornament than usual.

CHAMA GRYPHOIDES, *Linn., var.* GRYPHINA. 2nd Sup., Tab.V, fig.1 *a*, *b*, *c*.

CHAMA GRYPHOIDES, *Linn.* Crag. Moll., vol. ii, p. 162, tab. xv, fig. 8.

Locality. Red Crag, Waldringfield.

The specimen here represented is from Mr. Canham's collection. This I have referred as above, believing it to be merely a reversed form produced by the adherence of the right valve instead of the left. The present specimen is from the Red Crag, but probably only so by derivation from the Coralline.

LUCINA CRASSIDENS, *S. Wood.* 2nd Sup., Tab. V, fig. 4 *a*, *b*.

Diameter, $\frac{5}{8}$ths of an inch.

Locality. Red Crag, Waldringfield.

This is from Dr. Reed's cabinet; and it is in all probability a derivative from some anterior formation. The specimen seems to be not only full grown, but probably an old individual with a thickened interior. It has a prominent umbo, with a very broad and thickened hinge area. I thought at first sight that it might have been a specimen of *Lucina uncinata*, an Eocene species, which has an elevated dorsal margin, but that shell is much larger when full grown, and it has not the broad hinge of our shell. The present specimen is quite smooth on the exterior, but it has probably been much rolled and abraded.

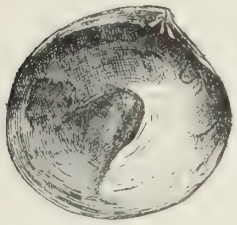
Another specimen of this genus, from the nodule workings in the Red Crag, which, from having both valves adherent and filled with indurated material, is clearly also a derivative, was given to me by Mr. Charlesworth many years ago, and this I believe to be *Lucina crassa* from the Kimmeridge Clay.

LUCINOPSIS LAJONKAIRII, *Payr*, var. SUBOBLIQUA. Figured in margin.

Locality. Cor. Crag, Ramsholt.

A single valve of this species was found by myself some time ago, which in the outline differs so widely from all other specimens I have seen, that I have had it

represented. It is suborbicular or slightly oblique, subequilateral, and much flatter than the ordinary form: the exterior is covered with the same radiating fine striæ, decussated by lines of growth, as are present on the ordinary form, with which also its dentition is identical; and it possesses the same impression or siphonal scar which is characteristic of *L. Lajonkairii*. As the differences presented by the present shell consist only in its greater flatness and different outline, I have regarded it as an accidental variety only; but if a series should be obtained maintaining these characters, they might be regarded as of specific value, and the above name, *subobliqua*, then be assigned specifically.



Lucinopsis Lajonkairii, *Payr.* *var.* subobliqua, *S. Wood.*

ASTARTE MUTABILIS, *S. Wood.* 2nd Sup., Tab. VI, fig. 1.

ASTARTE MUTABILIS, *S. Wood.* Crag Moll., vol. ii, p. 179, tab. xvi, fig. 1.

Diameter, 2 inches.

Locality. Cor. Crag, near Orford.

I have had the present specimen figured for its great size, showing the margin without crenulations. This freedom from crenulation has always been considered by myself a distinguishing mark denoting that the animal which formed the shell had not arrived at maturity, and I can see no reason against such a supposition. This is as large as the largest of any specimens I have of this species, and larger than many which have the margin ornamented with crenulations. So far as I have studied the shells of the genus *Astarte*, I have always found the young or immature specimens of a species, that is decidedly crenulated when full grown, to be without that peculiarity.

In the plate of the "Arctic Shells," in Sir E. Belcher's 'Arctic Voyage,' are the figures of two species of *Astarte*. Fig. 7 *a, b*, of Tab. XXXIII, is named and described as new under the name of *A. Richardsoni*. This is stated by Dr. Jeffreys, in 'Ann. and Mag. Nat. Hist.' for 1877, p. 234, to be the same as *A. crebricostata* of Forbes, but unless the figure given in Belcher's work be erroneous, it seems to me to be the common form of *Astarte borealis*, such as occurs in the East Anglian beds; while fig. 5 *a, b*, of the same Tab., called *A. fabula*, answers to the shell figured and described from the Red Crag as *A. crebrilirata*, 'Crag Moll.,' vol. ii, p. 184, tab. xvi, fig. 2, and which would thus appear to be living in the Arctic seas.

MACTRA PONDEROSA? *Stimpson.* 2nd Sup., Tab. VI, fig. 2.

MACTRA PONDEROSA, *Stimpson.* Shells of New England.

Dimensions, 2 inches by $1\frac{3}{4}$.

Locality. Red Crag, Waldringfield.

A specimen of *Mactra* has been sent to me by Dr. Reed, with the above name and locality attached by (I believe) Mr. A. Bell. It is unknown to me either as recent or fossil, but it deserves a representation. Its form and appearance much resemble a large specimen of *M. solida*, and is different from *M. solidissima* (*M. ovalis*, Gould), 'Inv. Massach.,' p. 53, fig. 32, but it is not very far removed from it.

MACTRA ARCUATA, *J. Sow.* Crag Moll., vol. ii, p. 243, Tab. XXIII, fig. 5; 1st Sup., p. 155.

I omitted to point out in my first Supplement that this species belongs to a section of the *Mactræ*, which the late Dr. J. E. Gray proposed to distinguish as a separate genus under the name of *Spisula*, this section being distinguished by the possession of the fimbriated mark or perpendicular striation on the lateral teeth, which forms part of the diagnosis of this species given at p. 243 of the 'Crag Moll.'; and that *Mactra glauca*, of which *arcuata* is called a variety in the list which accompanies Mr. Prestwich's paper on the Crag, belongs to the other section, viz. that which is destitute of this impression.

A fragment of a full-grown shell, showing the hinge with this fimbriated mark, and which therefore seems to be one of *M. arcuata*, was obtained by my son from a band of shell fragments at the top of the Middle Glacial sand, three or four feet below the overlying chalky clay, in a well at Bealings, near Woodbridge, this seam exactly corresponding in position to that at Billockby and Hopton, from which the species given in my first Supplement were obtained.

THRACIA PAPYRACEA, *Poli.* 2nd Sup., Tab. VI, fig. 6 *a*, *b*.

THRACIA PHASEOLINA. Crag Moll., vol. ii, p. 259, tab. xxvi, fig. 2.
— PAPYRACEA. 1st Sup. to do., p. 156.

Additional localities. Chillesford Bed, Sudbourn Church Walks; Lower Glacial, Belaugh.

Dr. Reed having sent to me a specimen with the name *Thracia villosiuscula* attached,

upon which that name as a variety of *T. papyracea* had been introduced into the list by Mr. A. Bell in the 2nd vol. of the 'Proceedings of the Geol. Association,' I have had it figured as above (6 *b*), and with it one of my own from the same locality, exhibiting the ordinary form of *papyracea* (6 *a*).

T. villosiuscula is considered both by Forbes and Hanley and by Dr. Jeffreys as a variety of *papyracea*, as being more equilateral than the typical form of that species, but the specimen sent me by Dr. Reed is rather less equilateral than the typical form. The species itself is difficult of distinction from the young of *T. pubescens*.

I also possess a perfect specimen of this shell from the Lower Glacial sand ofBelaugh.

THRACIA VENTRICOSA, *Phil.* 2nd Sup., Tab. V, fig. 3; Crag Moll., vol. ii, p. 262, Tab. XXVI, fig. 5; 1st Sup., p. 156.

Locality. Cor. Crag, Ramsholt.

In the list of the Crag shells appended to Mr. Prestwich's paper, p. 141, the one I called by the above name is said to be *Thracia convexa*, W. Wood, and I have in consequence figured a specimen obtained by myself from the Cor. Crag of Ramsholt. I thought, and still think, that the differences between the Crag shell and *T. convexa* are sufficient for their being kept distinct, and the specimen now figured exhibits these differences better than that figured in my original work; they consist in *ventricosa* having a far greater length of the posterior part of the shell and a less tumidity of the anterior. Indeed, the form of *ventricosa* is nearer to that of *pubescens* than it is to *convexa*.

In this, as in many other similar cases of living species approaching the Crag form, *T. convexa* may be the descendant of *T. ventricosa*, but if so the time which has elapsed since the deposit of the Coralline Crag has been sufficient to produce those differences, which, as I have pointed out in the concluding remarks of my first Supplement (p. 192), I consider should justify us in designating species as distinct.

PHOLAS INTERMEDIA, *S. Wood.* 2nd Sup., Tab. VI, fig. 7; Tab. V, fig. 2 *a*—*c*.

Dimensions. Length, 2 inches. Breadth of valve, $1\frac{3}{16}$ inch.

Localities. Cor. Crag, Gedgrave; Red Crag, Waldringfield.

The specimen represented in Tab. V, fig. 2, is in the collection of Mr. Canham, now in the Ipswich Museum, and was obtained from the phosphatic nodule pits at Waldringfield. As the valves are held together by the Red Crag material within them, I infer that the specimen died in the Red Crag, the material of which occupied the cavity

as the animal decayed, though the valves are not precisely adherent as they are in life. But for this I should have supposed it to have been a derivative from the Coralline Crag, from which the smaller specimen shown in fig. 7 of Tab. VI was obtained. I at first thought that it might be the same as the *Pholas brevis* from the Cor. Crag, of which I was enabled to figure a fragment in my first Sup. (Tab. X, fig. 24); but the differences are so great that I cannot regard the two as identical. Both shells, however, belong to the true genus *Pholas*, and not to that section of it called *Zirphea*, which was proposed as a separate genus by the late Dr. J. E. Gray; and in which the rays are confined to the anterior portion of the shell, and are bounded by a deep sulcus; and to which section *P. crispata* belongs.

The specimen, consisting of a single and smaller valve, which is represented in Tab. VI, fig. 7, was sent to me by Dr. Reed, with the name of *Pholas parva* attached, as from the Coralline Crag of Gedgrave, but it seems so closely to resemble the large shell from the Red Crag, represented in Tab. V, fig. 2, that I think it must be the younger state of it. It differs from *parva* in being considerably shorter in proportion to its breadth, the figure of that species from the Red Crag, given in the first Sup., Tab. X, being taken from a specimen which had been somewhat distorted by confinement in the crypt, and I have not seen that species in the Coralline Crag. I think it possible that the small specimen represented in fig. 24*b* of Tab. X of my first Supplement, may be a still younger state of our present shell instead of, as supposed in that Supplement, the young of the shell represented in fig. 24*a* of the same plate (and which I retain as *Pholas brevis*), as it has a similar deep opening for the foot; but a good series is required for a satisfactory determination of that question.

Pholas dactylus, Linn., has been given as a species from the Red Crag in Mr. Prestwich's paper 'Quart. Jour. Geol. Soc.,' vol. xxvii, p. 485, and by Mr. Bell in his paper on the English Crags, 'Proc. Geol. Assoc.,' vol. ii, No. 5, p. 26, from the "Middle (or Oldest Red) Crag." I have procured from Dr. Reed the specimen upon which this identification was based, and which has the locality of Walton Naze marked upon it, and to set the subject at rest I have had it represented in fig. 5 of Tab. V. The specimen exhibits unequivocally those characteristics which I have pointed out at p. 295 of the second volume of the 'Crag Mollusca' as distinguishing *cylindrica* from *dactylus*, and there can be no question of its being the common Walton species, *Ph. cylindrica*, J. Sow. In the list[1] given in the lately published memoir of the 'Geol. Survey,' for half sheet No. 48, this species is introduced, but this is probably only by adoption from the

[1] There are some errors in this list, even as regards Walton; but that part of it which refers to Beaumont (and which I presume is merely a repetition of the late Mr. John Brown's list of shells obtained from that locality) is, in my opinion, quite untrustworthy. *Pyrula uniplicata*, Duj., given in the memoir list, is probably a clerical error for some other shell, possibly *Pyramidella unisulcata*, which in Mr. Prestwich's *Coralline* Crag list is regarded as identical with *P. læviuscula*, but which I do not consider to exist in any part of the Crag. There is also a clerical error in respect of that shell in Mr. Prestwich's *Red* Crag list.

list in Mr. Prestwich's paper, in which the name was introduced from the specimen of *cylindrica* now under consideration. *Pholas lata* is also given in the same memoir as from Beaumont, but I do not know such a species unless it be *Pholas crispata*, to which shell the name of *lata* was given by Lister (see the synonyms of that shell in vol. ii of 'Crag. Moll.,' p. 296).

Venus dysera, Brocchi, and *Venus fasciata*, Dacosta, are given by Mr. A. Bell from the Cor. Crag, but I believe the former of these to be the young state of *Venus imbricata*, a specimen of which I had represented in 'Crag Moll.,' vol. ii, Tab. XIX, fig. 3 *b*. This may *possibly* be, in the young condition, undistinguishable from *V. fasciata*, but I have not yet seen any specimen from the Cor. Crag that could be pronounced positively as identical with that species. The young of many proximate but distinct species so closely resemble each other as to be incapable, in that state, of separation, the specific distinction only appearing as the animal advances in growth. I cannot therefore admit *dysera* into my list at all, nor *fasciata* into it as a Cor. Crag shell.

BRACHIOPODA.

Dr. Jeffreys has recently described several species of *Brachiopoda* that were obtained by the deep-sea dredgings during the expeditions of H.M.S. "Lightning" and "Porcupine," and he has figured them in the 'Proceedings of the Zool. Soc.,' April 16th, 1878. One of these species, to which he has given the name of *Terebratula trigona*, Plate xxii, fig. 3, very strongly resembles a small specimen that I found in the Cor. Crag of Sutton, and which is figured in my first Supplement, Tab. xi, fig. 3 *c*, and there considered as a young or small variety of *Terebratulina caput serpentis*, and I am disposed to think that if the crag fossil could be compared with the recent shell they might perhaps be specifically united. I cannot say if there be any difference in the form of the loop in my specimen, as I am unable to separate the valves of the only one at present known to me. I have also figured another specimen from the Cor. Crag in the same plate (fig. 3 *d*) as *caput serpentis*, but this is so abnormal that when more and similar specimens are found it may be perhaps entitled to specific distinction, and be called *anceps*. At p. 169 of my first Supplement I have pointed out that the beak of this latter shell has the form of that possessed by *Rhynconella*. In the 'Quarterly Journ. of the Geol. Society,' vol. xxvii, p. 137, Dr. Jeffreys says that the *Discina* from the Cor. Crag is the same species as *Discina Atlantica*, King; possibly this may be so, but, as in the case of the above *Terebratulina*, better evidence than we at present possess will be necessary for the correct determination of the question. The only two specimens of the Crag *Discina* that I know, or have heard of, were found by myself, and these are both upper valves. One of them is that figured by Mr. Davidson in 1852, also in Tab. XI of my first Supplement, and is in the collection of Crag Mollusca which I gave to the British Museum, and this is not perfect. The other (which is in my own cabinet) I found subsequently, and in this the characters are obscured by the shell being covered with a mass of *Cellepora*.

MEMORANDUM.

The following species, all contained in my original synoptical list, have also since occurred in beds represented in its columns beyond what is there shown.

In the Red Crag of Sutton and Butley.—*Nassa conglobata*. A solitary specimen found at Walton thirty-five years ago by Mr. Charlesworth, and in my collection in the British Museum, was the only instance of this shell known to me until lately. In Mr. Canham's collection, however, I observed a specimen from the Red Crag of Sutton; and it seems to me, therefore, that although it has not yet occurred in the Coralline Crag, this shell is properly a species of that Crag, and not of the Red, and is only present in the latter (albeit that it has occurred at Walton) by derivation from the Coralline.

In the Chillesford beds.—*Cardita corbis* and *Abra prismatica*. Mr. Dowson informs me that he has found several specimens of these shells at Aldeby.

In the Lower Glacial.—From a fossiliferous seam in the pebbly sands near Southwold Mr. Crowfoot has obtained several of the species given in my original list from these sands in Norfolk, and in addition *Cerithium tricinctum*, *Melampus* (Conovulus) *pyramidalis*, and *Donax vittatus*. Perfect specimens also of the latter from Belaugh and Weybourn are in my cabinet. An imperfect specimen of *Cardium* in my cabinet from Belaugh seems referable to *Cardium Islandicum*, but no reliance can be placed upon such fragments, either in this or other beds, for specific determination. Similarly, the fragments upon which the name of *C. Grœnlandicum* is inserted in the list of shells given by Mr. C. Reid from these sands where they underlie the Till along the Cromer coast (in the 'Geological Magazine' for July, 1877), are equally unreliable, and might be referred to more than one large species of *Cardium*. Whether *Islandicum* or *Grœnlandicum*, the Belaugh and Cromer fragments are probably those of the same species only, and would answer as well for the one as for the other of these shells. Mr. Crowfoot also

gives the name *Grœnlandicum* among those of the species obtained by him from the pebbly sands at Southwold. *Astarte sulcata*, *Ostrea edulis*, and *Pleurotoma turricula* are also given by Mr. C. Reid as having been found by him in these sands on the Cromer coast.

In the Middle Glacial.—*Hydrobia ulvæ*. A specimen of this shell was found by Mr. Harmer at Lound, near Yarmouth, in association with some of the commoner species of this deposit.

In the March Gravel.—*Tellina lata*. A small specimen of this shell from March is in the Cambridge Museum. Mr. Harmer has found the freshwater shell, *Cyrena fluminalis*, in numbers in this gravel, associated with *Cardium edulis* and other marine shells; an association corresponding to that which occurs in the Hessle gravel at Kelsea Hill in Yorkshire.

ADDITION TO THE SYNOPTICAL LIST GIVEN AT PAGE 203 OF FIRST SUPPLEMENT TO "THE CRAG MOLLUSCA."

Species and varieties new to the Synoptical List are in Roman letters. Species already in the Synoptical List are in italics, and are only inserted to indicate their occurrence in some one or other of the formations, referred to in the separate columns, beyond what is specified in the original list. Such of the latter as are marked † are given in the Lower Glacial column, on the authority *only* of Mr. C. Reid's paper, on the "Cromer Pliocene," in the 'Geological Magazine' for July, 1877.

Page in 2nd Supp.		Cor. Crag.	Red Crag, Walton.	Red Crag, Sutton and Butley.	Scrobicularia Crag.	Fluvio-marine Crag.	Chillesford Beds.	Lower Glacial.	Middle Glacial.	Upper Glacial.	Post Glacial, Kelsey.	Post Glacial, March.	Post Glacial, Hunstanton.	Post Glacial, Nar Brickearth.	Living, Britain.	Living, Mediterranean.	Living, elsewhere.	REMARKS.
4	Columbella sulculata, *S. Wood*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
2	*Nassa prismatica*, Broc.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	×	×	
4	— *incrassata*, Müll., var. tumida.	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
4	— angulata? *Broc.*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
52	— *conglobata*, Broc.	?	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	Derivative in Red Crag of Sutton; possibly derivative also at Walton.
3	— microstoma, *S. Wood* (*N. prismatica*, var. *limata*).	×	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
2	*Buccinum Dalei* ? J. Sow., var. distorta.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
1	— *undatum*, Linn., var. distorta	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
	— — var. *tenerum*	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	*B. Grænlandicum*, Chem. sec. Jeffreys Ann. and Mag. Nat. Hist., 1876, p. 323.
1	— nudum, *S. Wood*	×	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...	
2	— declive, *S. Wood*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
13	Murex Reedii, *S. Wood*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
15	— recticanalis, *S. Wood*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
15	— Crowfootii, *S. Wood*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
14	— pseudo Nystii, *S. Wood*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
16	Ranella ? Anglica, *A. Bell*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	Derivative.
15	*Triton connectens* ? S. Wood	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	Derivative in Red Crag.
9	Fusus Waelii, *Nyst*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
11	— obscurus, *S. Wood*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
12	— nodifer, *A. Bell*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
11	— ? exacutus, *S. Wood*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Derivative.
6	Trophon(Sipho)Islandicus, *Gmel.*	...	...	×	...	...	...	...	...	...	...	...	...	...	×	...	×	
7	— (—) *gracilis*, Da Costa	×	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
6	— (—) tortuosus, *L. Reeve*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	×	
7	— (—) Olavii, *Beck*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	×	
9	— Kröyeri, *Moll.*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	×	
8	— pseudo Turtoni, *S. Wood*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	*Trophon Norvegicus* of the synoptical list.
16	Pleurotoma Morreni, *De Konink*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	Derivative at Waldringfield.
18	— *teres*, Forbes	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
18	— gracilicostata, *S. Wood*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
17	— curtistoma, *A. Bell*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
21	— pannus, *Bast.*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
20	— *senilis*, S. Wood	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	Derivative.
20	— catenata, *A. Bell*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Possibly the same as *pannus*.
	† — *turricula*, Mont.	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
22	Cancellaria (Admete) Avara ? *Say*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	×	
22	— crassistriata, *A. Bell*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	Derivative.
39	Cerithium derivatum, *S. Wood*	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	Derivative.
23	— Greenii ? *Adams*	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	×	
52	— *tricinctum.* Broc.	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
27	Turritella Taurinensis, *Mich.*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	Derivative.
27	— *incrassata*, var. acutangula ? Broc.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
27	— — var. subangulata, Broc.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
25	Scalaria torulosa, *Broc.*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
26	— geniculata ? *Broc.*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	

Page in 2nd Supp.		Cor. Crag.	Red Crag, Walton.	Red Crag, Sutton and Butley.	Scrobicularia Crag.	Fluvio-marine Crag.	Chillesford Beds.	Lower Glacial.	Middle Glacial.	Upper Glacial.	Post Glacial, Kelsey.	Post Glacial, March.	Post Glacial, Hanstanton.	Post Glacial, Nar Brickearth.	Living, Britain.	Living, Mediterranean.	Living elsewhere.	REMARKS.
24	Chemnitzia senistriata, *S. Wood*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
24	— *internodula*, S. Wood, var. ligata.	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
39	Odostomia derivata, *S. Wood*...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	Derivative.
28	Eulima Hebe, *Semper*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
29	— subula, *D'Orb*.....	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
27	— Naumanni ? *von Könen*...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
28	— robusta, *A. Bell*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	Derivative ?
29	Rissoa parva ? *Da Costa*.....	×	...	...	...	...	...	...	...	...	...	...	...	...	×	×	×	
29	— costulata, *Alder*.....	×	...	...	...	...	...	...	...	...	...	...	...	...	×	×	×	
40	— *proxima*, Alder	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
35	Assiminea Grayana, *Leach*	...	...	...	...	×	...	...	...	...	...	...	...	...	×	...	...	
30	Hydrobia obtusa, *Sandberger*...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
53	— *ulvæ*, Penn.....	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	In the middle glacial of Lound.
33	Amaura hesterna, *S. Wood*.....	?	...	?	...	...	...	...	...	...	...	...	...	...	...	...	...	Doubtful whether from the Cor. Crag or from the Red of Butley, &c.
30	Natica (Amauropsis) Japonica ? *A. Adams.*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	×	
31	— triseriata ? *Say*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	×	
32	— *helicina* var heliciformis, *S. Wood*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
31	— *Groenlandica*, Beck, *var.* declivis.	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
34	Adeorbis ? naticoides, *S. Wood*	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	A very doubtful species.
38	Melampus fusiformis, *S. Wood*, *var.* elongatus.	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	Derivative ?
52	— *pyramidalis*, J. Sow.	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	Rackheath; Southwold; and, according to Mr. Reid, Runton.
	BIVALVIA.																	
41	Ostrea ungulata, *Nyst*.....	×	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
53	† — *edulis*, Linn.	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
43	*Mytilus edulis, var.* ungulatus...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
42	— — *var.* galloprovincialis	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
43	*Pectunculus pilosus*, var. insubricus, Broc.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
43	— *var.* nummarius, Broc. ...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
44	Nucula turgens, *S. Wood*	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	Derivative ?
45	Lucina crassidens, *S. Wood* ...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	Derivative.
45	*Lucinopsis Lajonkairii*, Payr., *var.* subobliqua.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
45	*Chama gryphoides, Linn.*, *var.* gryphina.	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	Derivative in Red Crag.
52	*Cardita cordis*, Phil.....	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	Aldeby.
52	*Cardium Islandicum* ? Linn. ...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
53	†*Astarte sulcata*, Da Costa	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
52	*Donax vittatus*, Da Costa ... (*anatinus*. F. & H.)	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	Belaugh and Weybourne; also, according to Mr. C. Reid, from Runton.
53	*Tellina lata*, Gmel.	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	A specimen from the March gravel in the Cambridge Museum.
52	*Abra prismatica*, Mont.	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	Several specimens from Aldeby.
47	Mactra ponderosa ? *Stimpson*...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
47	— *arcuata*, J. Sow.....	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	
47	*Thracia papyracea*, Poli.....	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	Perfect from Belaugh.
48	Pholas intermedia, *S. Wood.* ...	×	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	

The following species should be omitted from the Synoptical List altogether, viz. *Trophon Norvegicus*, see p. 7; *Pleurotoma violacea*, see p. 20; and *Pholas dactylus*, see p. 49; and from the Coralline and Red Crag columns of the list, *Ostrea edulis*, see p. 42.

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„ *sexcostatus*, Beyr.	10
„ Waelii, *Nyst*	9
Hydrobia obtusa, *Sandberger*	30
Lachesis Anglica, *A. Bell*	5
Limnæa auricularia, *Linn.*	36
„ palustris, *Müller*	37
„ peregra, *Müller*	37
Lucina crassa, J. Sow.	45
„ crassidens, *S. Wood*	45
„ *uncinata*, *Defr.*	45
Lucinopsis Lajonkairii, *Payr*	46
Mactra ponderosa ? *Stimpson*	47
Margarita *helicina*, Fabr.	36
Melampus fusiformis, *S. Wood*	38
Murex Crowfootii, *S. Wood*	15
„ *Haidingeri*, Hörnes	14
„ pseudo-Nystii, *S. Wood*	14
„ recticanalis, *S. Wood*	15
„ Reedii, *S. Wood*	13
„ *tortuosus*, J. Sowerby	13
Mytilus edulis, var. ungulatus	43
„ „ var. galloprovincialis	42

	PAGE
Natica Grœnlandica? var. declivis	31
„ heliciformis, *S. Wood*	33
„ Japonica? *A Adams*	30
„ triseriata? *Say*	31
Nassa angulata? *Brocchi*	4
„ consociata, *S. Wood*	4
„ *elegans*, Dujardin	3
„ incrassata, var. tumida	4
„ microstoma, *S. Wood*	3
„ prismatica, *Brocchi*	2
Nucula turgens, *S. Wood*	44
Ostrea hippopus, Lam.	42
„ ungulata, *Nyst*	41
Odostomia derivata, *S. Wood*	39
Pectunculus insubricus	43
Pholas *dactylus*, Linn	49
„ intermedia, *S. Wood*	48
„ *lata*	49
„ *parva*	49
Pleurotoma *Arctica?* Adams	20
„ catenata, *A. Bell*	20
„ *coronata*, Bellardi	19
„ curtistoma, *A. Bell*	17
„ gracilicosta, *S. Wood*	18
„ *Hosiusii*, Von Konen	19
„ Icenorum, *S. Wood*	19
„ intorta, *Brocchi*	17
„ *lævigata*, Phil.	22
„ Morreni, *De Konninck*	16
„ pannus, *Basterot*	21
„ senilis, *S. Wood*	20
„ teres? *Forbes*	18
„ *umbilicata, A. Bell*	19
Pupa edentula, *Drap.*	37
Purpura lapillus, *Linn*	5
Pyrgiscus Leunissii, Phil.	25
Pyrula *uniplicata*	49
Ranella? Anglica, *A. Bell*	16
Rissoa costellata, *Alder*	29
„ parva, *Da Costa*	29
„ reticulata, *Mont.*	30
Scalaria fimbriosa, *S. Wood*	25
„ geniculata? *Broc.*	26
„ torulosa, *Broc.*	25
Terebratula anceps, *S. Wood*	51
„ *trigona*? Jeff.	51
Thracia papyracea, *Poli*	47
„ ventricosa, *Phil.*	48
„ villosiuscula, *McGill*	48
Triton connectens, *S. Wood*	15
Trochus ziziphinus, *Linn*	35
Trophon altus, *S. Wood*	8
„ Islandicus, *Chem.*	6
„ Kröyeri? *Möller*	9
„ pseudo-Turtoni, *S. Wood*	8
„ tortuosus, *L. Reeve*	6
Turritella incrassata, *J. Sow.*	27
„ „ var. acutangula	27
„ „ „ subangulata	27
„ penepolaris, *S. Wood*	26
„ Taurinensis? *Mich.*	27
Venus *dysera*, Broc	50
„ *fasciata*, Da Costa	50
Valvata cristata, *Müller*	36
„ piscinalis, *Müller*	36

PLATE I.

Fig.	*Names of the shells.*	page	*Localities from which the specimens figured were obtained.*
1, *a*, *b*.	*Buccinum nudum* . . .	1	Cor. Crag, Sutton.
2, *a*, *b*.	— *Dalei ?* (distorted)	2	Cor. Crag, Sutton.
3.	*Columbella ?* (*Astyris*) *sulculata*	4	Red Crag, Shottisham.
4.	*Nassa microstoma* . . .	3	Cor. Crag ? Boyton.
5, *a*, *b*.	*Buccinum undatum ?* (distorted)	1	Red Crag, Butley.
6.	*Nassa prismatica* . . .	2	Cor. Crag, Sutton.
7, *a*, *b*.	*Murex recticanalis* . . .	15	Cor. Crag, Sutton.
8, *a*, *b*.	— *pseudo-Nystii* . .	14	Cor. Crag ? Boyton.
9, *a*, *b*.	— *Reedii*	13	Cor. Crag ? Boyton.
10, *a*, *b*, *c*.	*Fusus Waelii*	9	Cor. Crag ? Boyton.
11.	*Trophon altus*	8	Red Crag, Butley.
12, *a*, *b*.	*Fusus obscurus*	11	Cor. Crag ? Boyton.
13.	*Purpura lapillus* . . .	5	Fluvio-marine, Bramerton.
14, *a*, *b*.	*Triton connectens ?* . . .	15	Red Crag, Waldringfield.
15.	*Murex Crowfootii* . . .	15	Cor. Crag ? Boyton.

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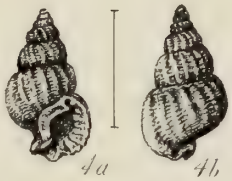
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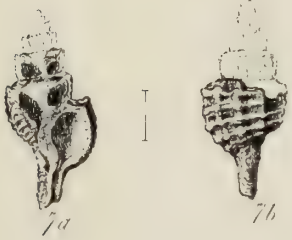
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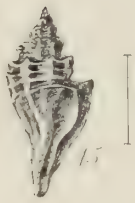
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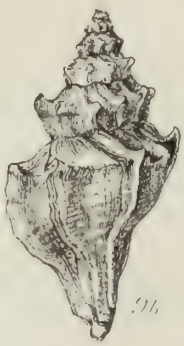
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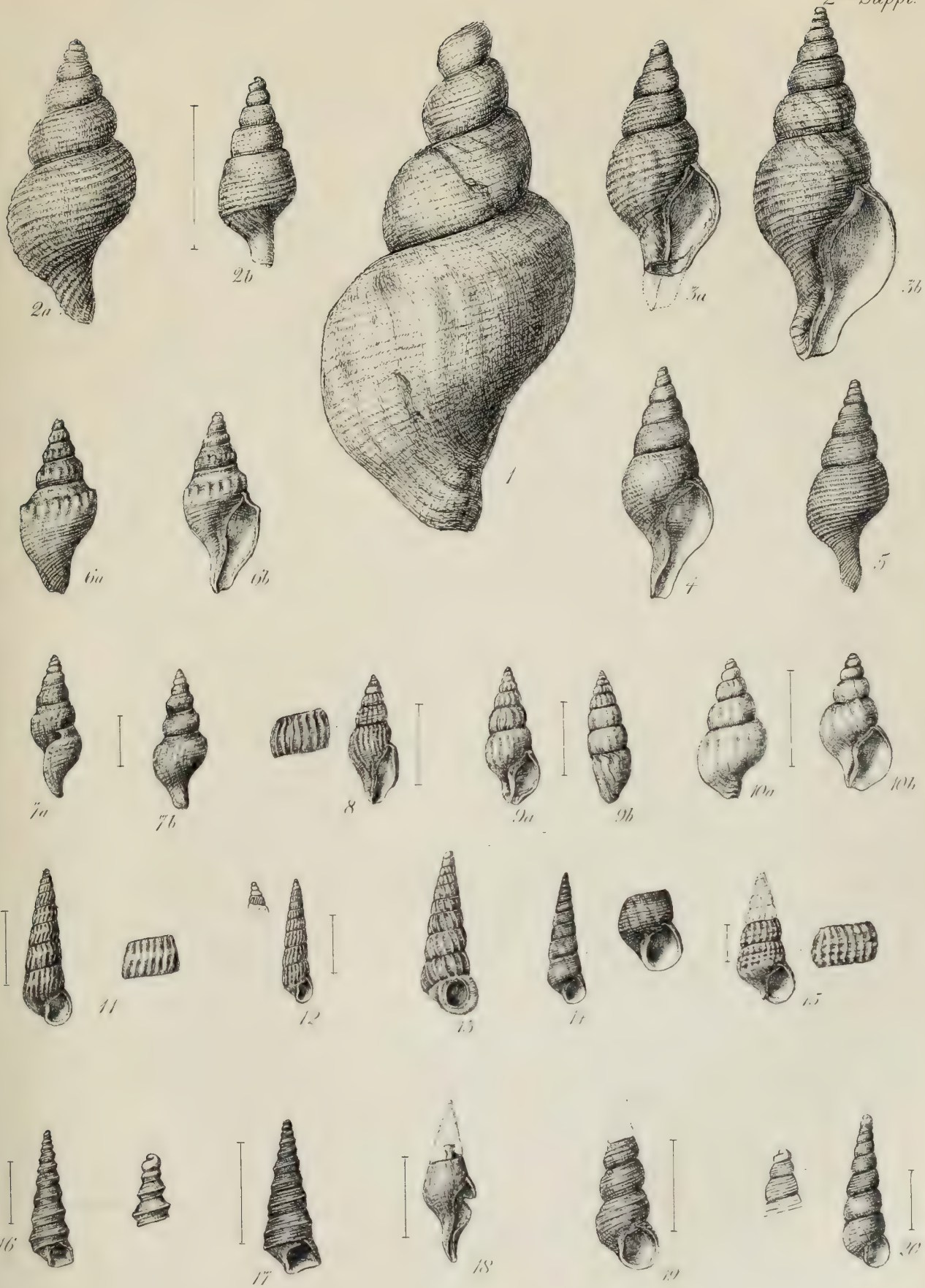
13a

11a

11b

PLATE II.

Fig.	*Names of the shells.*	page	*Localities from which the specimens figured were obtained.*
1.	*Trophon pseudo-Turtoni* .	8	Red Crag, Waldringfield.
2, *a*.	— *tortuosus* . . .	6	Red Crag, Waldringfield.
2, *b*.	— — var. .	6	Red Crag, Sutton.
3, *a*.	— *Islandicus* . . .	6	Red Crag, Sutton.
3, *b*.	— — . . .	6	A recent specimen.
4.	— *gracilis*	7	Cor. Crag, Gedgrave.
5.	— *propinquus* . . .	7	Cor. Crag, Gedgrave.
6, *a*, *b*.	*Pleurotoma Morreni* . .	16	Red Crag, Waldringfield.
7, *a*, *b*.	— *teres* . . .	18	Cor. Crag, Sutton.
8.	— *gracilicostata* .	18	Cor. Crag, Sutton.
9, *a*, *b*.	— *curtistoma*? .	17	Cor. Crag? Gedgrave.
10, *a*, *b*.	*Buccinum declive* . . .	2	Cor. Crag? Boyton.
11.	*Chemnitzia internodula* var. *ligata*	24	Fluv.-mar. Crag, Bramerton.
12.	— — .	24	Cor. Crag, Sutton.
13.	*Scalaria torulosa* . . .	25	Cor. Crag? Boyton.
14.	*Turritella* (*Mesalia*) *penepolaris*	26	Cor. Crag? Boyton.
15.	*Cerithium variculosum* . .	23	Red Crag, Walton Naze.
16.	*Turritella incrassata*, var. *acutangulata*	27	Cor. Crag, Sutton.
17.	*Turritella incrassata*, var. *subangulata*	27	Cor. Crag, Sutton.
18.	*Fusus? exacutus* . . .	11	Cor. Crag, Sutton.
19.	*Turritella Taurinensis?* .	27	Red Crag, Sutton (derived).
20.	*Chemnitzia senistriata* . .	24	Cor. Crag, Sutton.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G. B. Sowerby

PLATE III.

Fig.	*Names of the shells.*	page	*Localities from which the specimens figured were obtained.*
1.	*Borsonia?*	21	Red Crag, Waldringfield.
2 *a, b.*	*Pleurotoma senilis* . . .	20	Red Crag, Sutton.
3.	*Ranella Anglica* . . .	16	Red Crag, Waldringfield (derived?).
4 *a, b.*	*Fusus nodifer*	12	Red Crag, Waldringfield (derived?).
5.	*Pleurotoma catenata* . .	20	Cor. Crag, Gedgrave.
6.	— *pannus* . .	21	Cor. Crag, near Orford.
7 *a, b.*	*Natica heliciformis* . .	32	Cor. Crag, Gedgrave.
8 *a, b.*	*Pleurotoma Icenorum* . .	19	Cor. Crag, near Orford.
9.*	*Trophon Kröyeri?* . .	9	Red Crag, Shottisham.
10.†	*Columbella sulcata* (deformed)	5	Red Crag, Walton Naze.
11 *a, b.*	*Natica* (*Amauropsis*) *Japonica*	30	Red Crag, Butley.
12, *a, b.*	*Natica Grœnlandica?* var. *declivis* . . .	31	Red Crag, Butley.
13 *a—c.*	*Adeorbis? naticoides* . .	34	Cor. Crag, Sutton.
14 *a, b.*	*Natica triseriata?* . . .	31	Red Crag, Butley.
15.	*Melampus fusiformis*, var. *elongatus*	38	Red Crag, Waldringfield.
16 *a, b.*	*Cancellaria crassistriata*	22	Red Crag, Waldringfield (derived?).
17 *a, b.*	*Scalaria fimbriosa* . . .	25	Cor. Crag, near Orford.
18.	*Assiminea Grayana?* . .	35	Fluvio-marine Crag, Bramerton.

* Referred to at p. 9 as Tab. III, fig. 8.

† Referred to at p. 5 as Tab. III, fig. 11.

PLATE IV.

Fig.	*Names of the shells.*	page	*Localities from which the specimens figured were obtained.*
1.	*Trophon pseudo-Turtoni* .	8	Red Crag, Waldringfield.
2, *a*, *b*.	*Limnæa palustris* . . .	37	Fluv.-mar. Crag, Bramerton.
3, *a*.	— *auricularia* . . .	36	Fluv.-mar. Crag, Bramerton.
b.	Figure of a recent specimen by mistake of the engraver		
4.	*Limnæa peregra* . . .	37	Fluv.-mar. Crag, Bramerton.
5.	*Cancellaria avara?* . .	22	Red Crag, Waldringfield.
6.	*Pupa edentula*	37	Fluv.-mar. Crag, Bramerton.
7.	*Hydrobia obtusa* . . .	30	Fluv.-mar. Crag, Bramerton.
8, *a*—*b*.	*Valvata cristata* . . .	36	Fluv.-mar. Crag, Bramerton.
9.	— *piscinalis* (*antiqua*) . . .	36	Fluv.-mar. Crag, Bramerton.
10.	*Bulimus lubricus* . . .	38	Red Crag, Butley.
11.	*Scalaria geniculata?* . .	26	Cor. Crag, Sutton.
12.	*Nassa granulata*, var. *nana*	4	Red Crag, Sutton.
13, *a*—*b*.	— *consociata* . .	4	Red Crag, Waldringfield.
14.	— *angulata?* . .	4	Red Crag? Boyton.
15.	— *incrassata*, var. *tumida* . . .	4	Red Crag, Butley.
16.	*Cerithium Greenii?* . .	23	Chillesford bed, Bramerton.
17.	*Eulima robusta* . . .	28	Red Crag, Waldringfield.
18.	— *Hebe*	28	Cor. Crag, Sutton.
19.	*Rissoa reticulata* . . .	30	Cor. Crag, Sutton.
20.	*Trochus ziziphinus*, var. .	34	Cor. Crag, Sutton.
21.	*Rissoa parva*	29	Cor. Crag, Sutton.
22.	*Eulima Naumanni?* . .	27	Cor. Crag, Sutton.
23.	*Rissoa costulata* . . .	29	Cor. Crag, Sutton.

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PLATE V.

Fig.	*Names of the shells.*	page	*Localities from which the specimens figured were obtained.*
1, *a*—*c*.	*Chama gryphoides*, var. *gryphina*	45	Red Crag, Waldringfield (derived).
2, *a*—*c*.	*Pholas intermedia* . . .	48	Red Crag, Waldringfield.
3.	*Thracia ventricosa* . . .	48	Cor. Crag, Ramsholt.
4, *a*—*b*.	*Lucina crassidens* . . .	45	Red Crag, Waldringfield ? (derived).
5.	*Pholas cylindrica* . . .	49	Red Crag, Walton Naze. Specimen to which the name of *dactylus* was assigned.
6, *a*, *b*.	*Nucula turgens*	44	Red Crag, Waldringfield ? (derived).
7, *a*.	*Ostrea ungulata* (outside lower valve)	41	Cor. Crag, Ramsholt.
7, *b*.	— — (inside upper valve)	41	Cor. Crag, Ramsholt.

The inside view of this oyster, not having been reversed by the Engraver, fig. 7 *b* presents an erroneous appearance, inasmuch as that the umbo of the valve should turn to the right instead of the left. Viewed by reflection in a mirror the representation will be found correct.

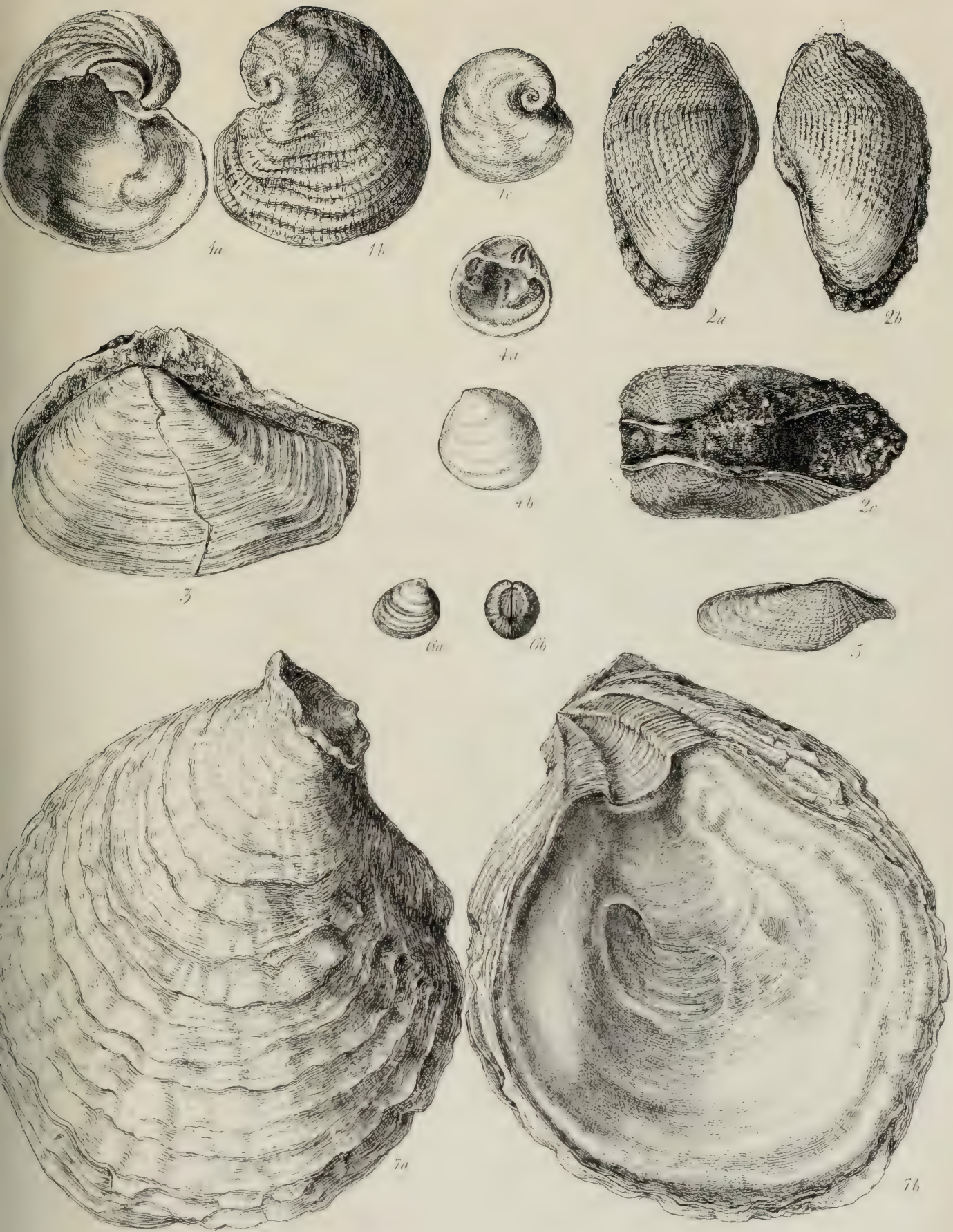

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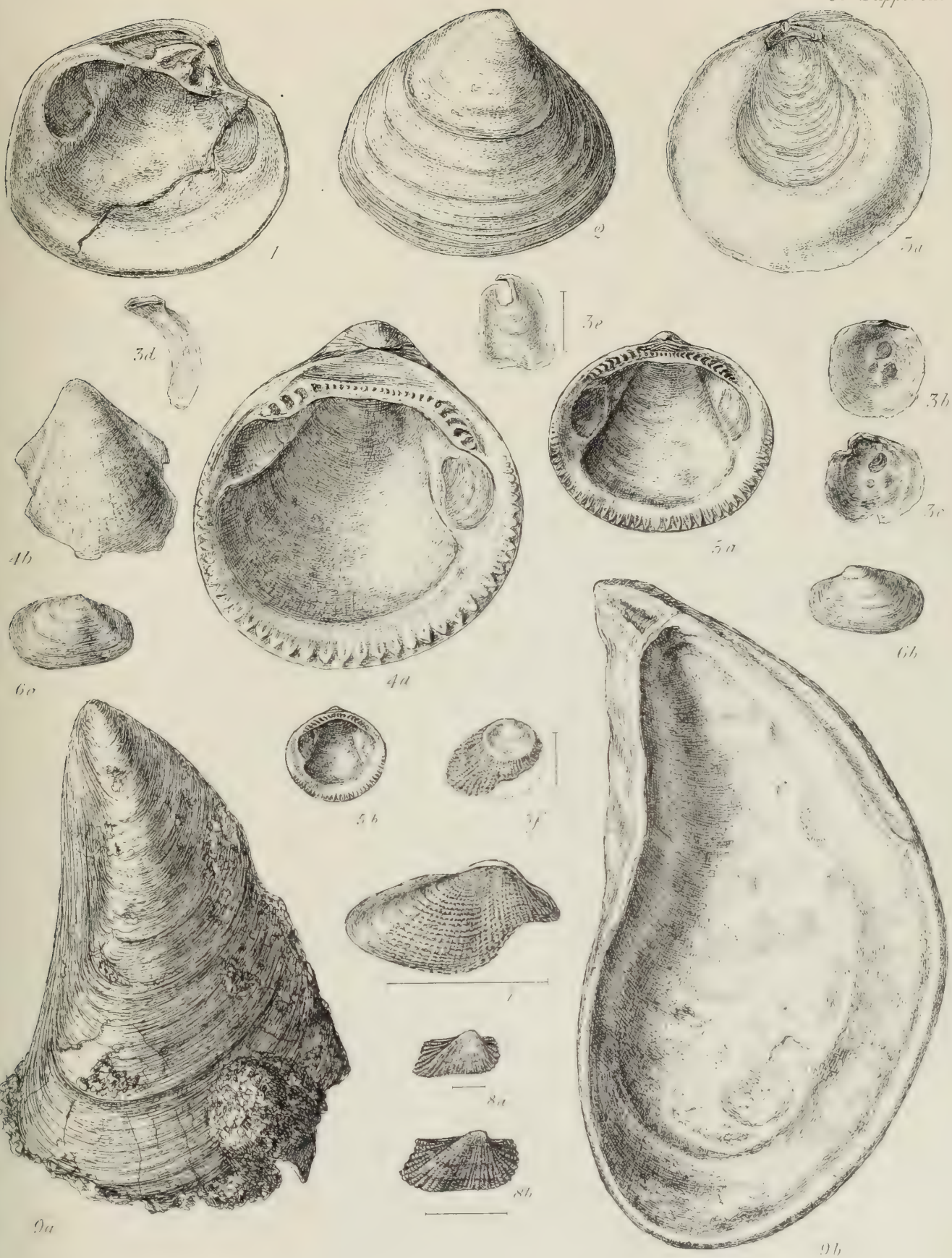
PLATE VI.

Fig.	*Names of the shells.*	page	*Localities from which the specimens figured were obtained,*
1.	*Astarte mutabilis*	46	Cor. Crag, near Orford.
2.	*Mactra ponderosa*	47	Red Crag, Waldringfield.
3 *a.*	*Anomia striata* (upper valve)	41	Cor. Crag. near Orford.
b.	— — (inside of upper valve)	41	Cor. Crag, Sutton.
d.	— — (thickened portion of lower valve) .	41	Cor. Crag, near Orford.
e.	— — (lower valve with opening) . . .	41	Cor. Crag, Sutton.
f.	— — (upper valve showing early part plain, afterwards striated) . .	41	Cor. Crag, Sutton.
4 *a.*	*Pectunculus pilosus*, var. *insubricus*)	43	Cor. Crag, Ramsholt.
b.	Inside lining of ditto . . .	43	Cor. Crag, Sutton.
5 *a.*	*Pectunculus glycimeris* . .	43	Cor. Crag, Sutton.
b.	— — var. *nummarius*	43	Cor. Crag, Sutton.
6 *a.*	*Thracia papyracea* juv. (*villosiuscula ?*)	47	Chillesford bed at Sudbourn Church Walks.
b.	— — juv. . .	47	Chillesford bed at Sudbourn Church Walks.
7.	*Pholas intermedia*	48	Cor. Crag, Gedgrave.
8 *a.*	*Arca tetragona*	44	Cor. Crag, Sutton.
b.	— —	44	Cor. Crag, Sutton. The specimen to which the names *A. puella* and *A. nodulosa* have been assigned.
9 *a.*	*Mytilus edulis*, var. *gallo-provincialis* . . .	42	Red Crag, Sutton.
b.	— — var. *ungulatus*	43	Cor. Crag ? Boyton.



G. B. Sowerby.

THE

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INSTITUTED MDCCCXLVII.

VOLUME FOR 1879.

LONDON:

MDCCCLXXIX.

A MONOGRAPH

OF THE

BRITISH FOSSIL TRIGONIÆ.

BY

JOHN LYCETT, L.R.C.P.E., &c.

No. V.

General Title-page; Preface; Pages 205—245; Plate XLI.

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INSTITUTED MDCCCXLVII.

LONDON:

MDCCCLXXII—MDCCCLXXIX.

THE FOSSIL TRIGONIÆ.

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53— 92	X—XIX	1874	July, 1874
93—148	XX—XXVII	1875	December, 1875
149—204	XXVIII—XL	1877	February, 1877
205—245	XLI	1879	May, 1879

A MONOGRAPH

OF THE

BRITISH FOSSIL TRIGONIÆ.

BY

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MEDICAL OFFICER OF THE ROYAL NORTHERN SEA-BATHING INFIRMARY, SCARBOROUGH; HONORARY MEMBER OF THE COTTESWOLD NATURALISTS' FIELD-CLUB.

LONDON:

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1872—1879.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE.

PREFATORY.

The introductory portion of this Monograph contains descriptions of all the sectional divisions of the genus with which the British Trigoniæ are connected. The sketch of species in *italics*[1] appended to these sectional divisions has been reconstructed and amended in the Stratigraphical Table[2] at the end of the Monograph, and to this the reader is referred. One division not referred to in the introductory portion is the living section of the genus, the "Pectinidæ" of Agassiz, a section which is special to one of our colonial possessions, being known only in Australia. This particular section will be found alluded to in the last few concluding pages of the Monograph.[3]

The importance of the Trigoniæ both zoologically and stratigraphically appears only lately to have been sufficiently estimated by either the naturalist or the geologist. The gradually increasing occurrence of these forms, and their relationship to the zoological assemblages with which they are connected, may be considered as so many features of constantly increasing interest and importance to science, whatever may be determined upon as to their status whether as species or varieties. It is only within the last few years that Tertiary Trigoniæ of the Pectinidæ group have been discovered in Australia. The Tertiary formations of the other continents are, as far as we yet know, entirely destitute of the genus.

JOHN LYCETT.

Scarborough;
10*th February*, 1879.

[1] Pages 5—13. [2] Pages 235—239. [3] Pages 231—234.

Trigonia costigera, *Lyc.* Plate XLI, fig. 17 (Mould).

I am indebted to Mr. C. J. A. Meÿer, F.G.S., for information respecting this imperfectly known species discovered by that gentlemen in the Chloritic Marl rocks of the South Devon Coast, near to Beer Head; the bed is No. 10 of Mr. Meÿer's classified section. Several examples have been observed larger than our Trigonia on Plate XLI; these, however, consisted only of impressions of the costæ. The small mould herewith figured is the only one hitherto obtained; it has some small portion of the shell attached, including three short, horizontal costæ upon the anteal portion of the valve; these have some traces of crenulations. The figure is ovately subtrigonal, moderately convex posteally and depressed anteally; there are some obscure indications of a marginal carina; the umbones are submesial, prominent, and pointed; the unusual shortness of the form is remarkable, the length and height being nearly equal; the abruptness of the posterior slope chiefly contributes to this peculiarity. These few features are insufficient to characterise the species, and its sectional position is somewhat doubtful. I am inclined to arrange it with that group of the *Scabræ* which includes *T. sulcataria*, *T. pennata*, *T. Meÿeri*, and *T. Nereis*, which have the posteal portions of the costæ small, sometimes ill defined, and bent upwards perpendicularly or at right angles to their anteal portions. None of these features are preserved upon our specimen, but in the absence of any well-grounded expectation that better specimens will be obtained I have ventured to figure this very defective shell.

Trigonia Blakei, *Lyc.*, sp. nov. Plate XLI, fig. 4.

Shell with the general figure ovately oblong; umbones prominent and pointed, placed at the boundary of the anteal third of the valve; posteal slope straight and lengthened; borders of the valves elliptically curved. Area moderately wide, somewhat concave, distinctly bipartite, with three slightly developed tuberculated carinæ. Escutcheon small and depressed. Costæ about thirteen; the first formed eight or nine are regular, closely arranged, and concentrically or elliptically curved, narrow, high-ridged, and imperfectly tuberculated; the last formed four or five costæ are more widely separated, and are more nearly horizontal, excepting their posteal portions, which have the tubercles, to the number of three or four, larger and more curved upwards, approaching the carina at a considerable angle.

Length 14 lines; height 11 lines; diameter through the single valve 4 lines.

The general figure and ornamentation approaches to *T. concentrica* Ag., but the rows of costæ are much less regularly and less distinctly tuberculated, the last formed rows more especially are very narrow, less moniliform, and more horizontal, excepting their

posteal portions; these differences apply equally to the figure of *T. concentrica* given by De Loriol and Pellat, 'Portl. de Boulogne,' pl. 8, fig. 2. The convexity of the last-named figure is also much more considerable than our British Calcareous Grit species.

Stratigraphical Position and Locality.—The passage-beds over the Lower Calcareous grit of Snainton, Yorkshire: accompanied by numerous Conchifera, including *Trigonia Snaintonensis* and *T. clavellata*. It appears to be rare, and only single valves have been collected. Obtained by W. H. Huddleston, Esq. The name is from the Rev. J. F. Blake, whose important contributions to the Geology and Palæontology of the Northern Counties of England are so well known.

Trigonia concentrica, *Ag.*

Since the notice of this species at p. 52 was written, no additional materials to illustrate it have come under my observation. The specimens first examined and provisionally assigned to it in 1870 were very imperfect, fragmentary, and altogether insufficient to characterise the species. The hope that more satisfactory and less doubtful specimens would be obtained not having been realised, it becomes necessary to remove *Trigonia concentrica* from the ascertained list of British Trigoniæ.

A nearly allied species, obtained by Mr. Huddleston in the passage-beds over the Lower Calcareous Grit of Snainton, may possibly be identical as a species with the fragmentary specimens alluded to. A good example figured upon Pl. XLI, fig 4, under the name of *T. Blakei*, has enabled me to correct the error upon page 52, and to describe a species of the Lower Calcareous Grit distinct from the *T. concentrica* of Agassiz and of De Loriol.

Trigonia paucicosta. Plate XI, figs. 8, 9; Plate XVI, fig. 7; Plate XXXVII, fig. 3, p. 57.

Trigonia angulata. Pl. xiv, figs. 5, 6; pl. xxxvii, figs. 7, 8, 9, p. 54.

Supplementary to the comparisons between these species at page 58, the number of specimens of *T. paucicosta* since obtained have been so considerable as to illustrate the distinctive differences with much certainty. With a species so variable in its surface-ornaments numerous examples are necessary to exemplify its aspects. I retain sixteen specimens, and have examined probably not less than a hundred; these, however, form but an inconsiderable portion of specimens destroyed in endeavouring to separate them from the hard Kelloway Rock at Cayton Bay. These numbers, collected over a very small surface area, evince the gregarious habits of the species. Unlike the Scarborough shell, the Inferior Oolite *T. angulata* was not gregarious; it has occurred at various localities

always very sparingly, and apparently is not limited to a single bed or horizon of that formation. Collected during the last half century by geologists and local observers it remains a somewhat rare species, and is absent in collections of Inferior Oolite fossils which are unconnected with the Cotteswolds.

Distinctive Differences.—T. paucicosta is the smaller of the two species; its general convexity is greater, the anterior side is shorter, giving to the umbones a more anteal position; the marginal carina in its upper portion has a row of well separated and rounded tubercles; these do not occur in *T. angulata*. The rows of costæ have much variability in both species, but more especially in *T. paucicosta;* usually these terminate posteally with two or three large nodes in each row, or these are sometimes united and become a single varix.

In *T. angulata* the posteal portions of the rows of costæ have much greater uniformity; in common with the *Undulatæ* generally they are subtuberculated, become attenuated, and curve upwards to the carina with a graceful undulation (see Pl. XIV, fig. 6; Pl. XXXVII, figs. 7, 8, 9). These differences indicate the propriety of a zoological not less than of a stratigraphical separation.

As a correction to p. 59, line 4, read, "few examples of *Trigonia paucicosta* have occurred at that locality."

Trigonia ingens, *Lyc.* Plate VIII, figs. 1, 2, 3; Plate XXXVI, figs. 5, 6, p. 24.

Trigonia ingens of the Middle Neocomian formation, compared with *T. signata* of the Inferior Oolite, Zieten's variety.

Subsequent to the publication of the figures and descriptions of *Trigonia ingens*, numerous fine examples, with the test preserved and representing every stage of growth, have been obtained by Mr. Keeping, of the Woodwardian Museum, Cambridge, in the Middle Neocomian formation at Acre House, near Tealby; the bed is a brown ferruginous pisolite; a portion of the rock worked for iron-ore at that locality is described by Professor J. W. Judd, 'Quart. Journ. Geol. Soc.,' vol. xxiii, p. 227. Two additional figures of small specimens from that locality will be found, Plate XXXVI, figs. 5, 6; the general aspect is altogether that of the Jurassic *Clavellatæ*, and bears so considerable a resemblance to British specimens of *T. signata* from the Inferior Oolite that without care it might be mistaken for that species.

Compared with the Jurassic shell the general figure has much greater convexity, or is more ovately oblong; the area is more narrow, steep, convex, and less expanded; its transverse plications are more prominent, rugose, and irregular; its bounding carinæ are less distinct, and sometimes disappear, or degenerate into plications; the position of the median carina is occupied by a groove; the umbones are smaller, more pointed, and anterior; the rows of costæ have less curvature, they are more nearly transverse or

approach to the horizontal figure, their tubercles are very irregular and unequal, always much elevated, and sometimes pointed or spinose. All the Lincolnshire specimens are remarkable for the regularity and uniformity of the rows of costæ; each row ends posteriorly with a tubercle, which is one of the largest, affording a marked contrast with the posteal extremities of the costæ in the Inferior Oolite species, in which they become attenuated, and curve upwards to the carina at a more considerable angle. An examination of very numerous Tealby specimens proves that the large Norfolk specimen (Plate VIII, fig. 1) represents the ultimate stage of growth, and that the little accessory costæ near the pallial border is altogether an exceptional feature, and is not represented in Tealby specimens.

Trigonia radiata, *Ben.* Page 73.

The remarks upon the French example of this species figured by Messrs. De Loriol and Pellat, 'Mon. Paléont. de l'étage Portlandien de Boulogne,' pl. 8, fig. 1, forming the concluding sentences of p. 73, require the following emendation. My friend Dr. Wright, who has compared the original specimen in the possession of M. De Loriol with the figure in the work of that author, informs me that the anteal portion of the specimen retains the test, which is therefore altogether devoid of ornamentation. The only undoubted British specimen known continues to be the one figured by Miss Benett.

Trigonia producta, *Lyc.* Pl. XIII, figs. 1, 2, 3, 4; Pl. XXXVII, figs. 1, 2, p. 60.

It having been objected to the figs. of this species on Plate XIII that they do not represent sufficiently the usual aspect of the Cotteswold forms, the two figures on Plate XXXVII are added, as they exhibit the more frequent condition in which the species occurs, together with the partial effacement of the surface ornaments over the middle portion of the valves. Plate XIII, fig. 3, represents the hinge-processes of the specimen, Plate XXXVII, fig. 1. Plate XIII, fig. 2, represents a specimen in an unusually fine condition of preservation, having the tubercles both of the costæ and carinæ, more than usually prominent for one of the *Undulatæ*, over the whole of the specimen.

In the Cotteswolds it is a rare Trigonia, and is limited in position to the hard whitish limestone of the Upper Trigonia beds, or to the sandy grits by which it is replaced. In Oxfordshire it has occurred less rarely, and has been collected by the Officers of the Geological Survey in the sandy beds at Hook Norton, associated with *Trigonia signata*. As a correction to p. 62, line 7, erase Northamptonshire and substitute Oxfordshire.

TRIGONIA IMBRICATA, *Sow.* Plate VI, fig. 5; Plate XXXVI, figs. 9, 10; also Plate XLI, figs. 10, 11, 12, p. 33.

The figures on Plates VI and XXXVI represent specimens obtained in the Great Oolite of Ancliff, and do not sufficiently express the little perpendicular pillars or elongations of the tubercles downwards in each, features which characterise the species. The figures on Plate XLI are drawings of Fullers Earth specimens, deprived of the test; they nevertheless expose the little characters indicated, and it is hoped therefore that they will aid in illustrating this species. The specimens have been procured by Mr. Witchell, who has kindly forwarded them to me to be used in this Monograph. Compared with an allied species, *T. tuberculosa*, Plate V, figs. 9, 10, the latter has the rows of tubercles much more closely arranged, and the area has transverse striations in lieu of the widely separated costellæ of *T. imbricata*.

Locality.—The Fullers Earth of Stroud, associated with *Trigonia Witchelli*, *Posidonomya opalina*, *Sowerbya triangularis*, and other Conchifera.

TRIGONIA BRONNII, *Ag.*

At p. 23 is a description of this species founded upon examples from the Coral Rag of Glos, Normandy. Professor Hébert, in his 'Memoir on certain Clavellated Trigoniæ of the Oxford Clay and Coral Rag,' there quoted, refers to four British specimens of *T. Bronnii* obtained in the Calcareous Grit of Weymouth. On examination some small examples of clavellated forms from the latter locality, in which the rows of costæ are nearly horizontal, appeared to coincide with some French examples of *T. Bronnii*, a species which has considerable variability even when obtained from a single locality. Subsequent comparisons and examinations of various Weymouth and French specimens have convinced me of the fallible character of this single distinctive feature, and of the necessity of merging all such Weymouth specimens in *T. clavellata*, to which species, therefore, fig. 8, Plate IV, should be referred; and *T. Bronnii* should be removed from the list of British species.

The subjoined figures represent a common or medium-sized example of *T. Bronnii* from Glos.

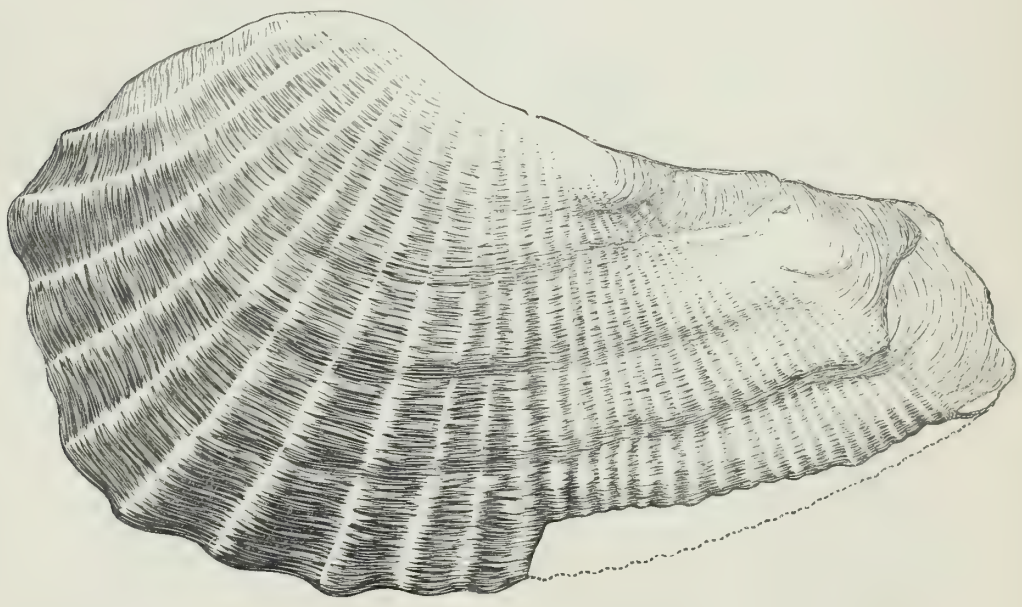
Trigonia Bronnii, Ag.

TRIGONIA CONOCARDIIFORMIS, *Krauss.*

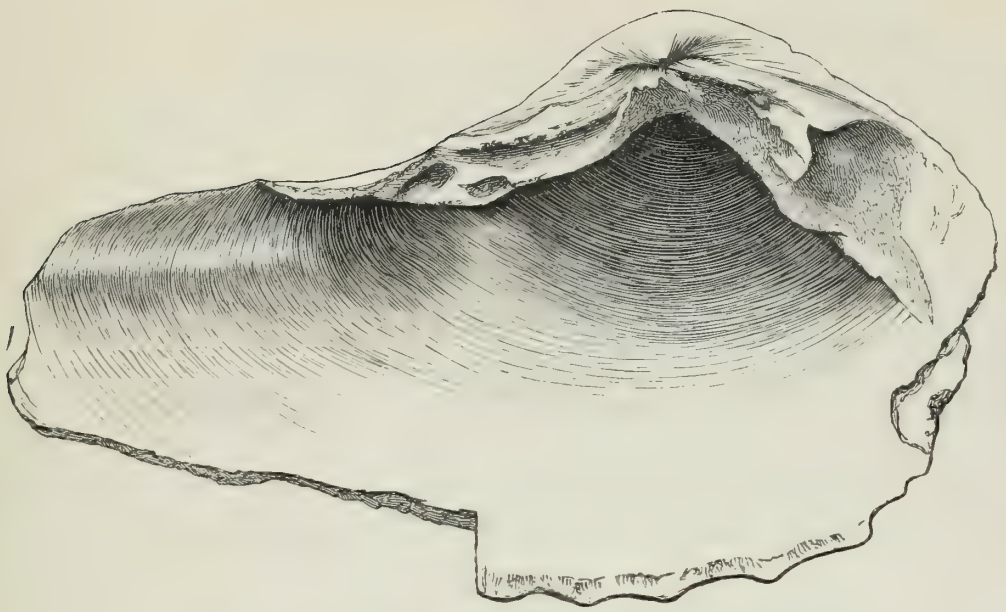
Of this remarkable species, so abundant in certain districts in Southern Africa, the single imperfect example in the British Museum is herewith figured. I have deemed it expedient to give the subjoined figures partly to correct an error induced by the reduced and inadequate figures given by Krauss, which appeared to me to represent one of the *Clavellatæ;* the Museum specimen undoubtedly associates it with the crenulated examples of the *Scabræ* (see pp. 120, 121).

The general figure is unusually lengthened; the numerous curved, slightly crenulated costæ, widely separated anteally, are much smaller and more closely arranged posteally; they all disappear upon the upper surface of the valve; the spaces representing the area and escutcheon are separated and apparently plain. The specimen, which is the only one known to me, is imperfect posteally, and would be slightly more lengthened when entire. The interior exhibits the hinge-processes and sulcations of the left valve, massive and spreading, but partially destroyed.

This gigantic species is not without a certain resemblance, both in the general figure and arrangement of the costæ, to the Belgian *T. Elisæ* of the Whetstones of Bracquegnies, but the larger anteal costæ are without the rounded papillary prominences of that species. The smaller posteal costæ are nearly straight and directed retrally, as in the smaller Belgian form.



Trigonia conocardiiformis, Krauss. South Africa.



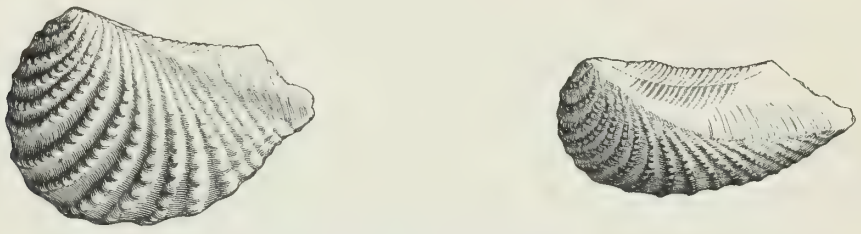
Trigonia conocardiiformis, Krauss. Inner surface of valve.

Comparison of the Trigoniæ of the Blackdown Beds with those of Bracquegnies.—The Whetstones (meule) of Bracquegnies, Belgium, are upon the same horizon, and are identical lithologically, for the most part, with the Blackdown Whetstones (Cornet and Briart, "Description de la Meule de Bracquegnies," 'Mémoires Couronnes et Mém. des Savants Étrangers,' Acad. Royale de Belgique, t. xxxiv, 1868). Like to the British deposits, they are characterised by the prevalence of *Trigonia dædalea*, Park., Cornet and Briart, pl. 6, figs. 1, 3. The numerous specimens have individual peculiarities, but they all differ from the usual Blackdown form, of which good illustrative examples are given upon our Plate XXIII, figs. 2 and 3, which represent specimens of full dimensions; the Belgian specimens are identical with our large variety *confusa* (Plate XXIII, fig. 1, p. 102). In Britain this variety is comparatively rare, and is found a little higher in stratigraphical position. In Devonshire it has occurred only at Little Haldon, at the base of the Upper Greensands, in a pebbly bed special to that region. The British Museum has upon its tablets a fine and varied series of adult forms of this large variety, which are exhibited as examples of *T. dædalea*. I have placed it as a variety, but possibly other observers may be inclined to regard it as a distinct species. The most prominent varietal features consist in the unusually large, confused, rounded tubercles, which cover and crowd the larger or posteal portion of the shell, and in the large tuberculated escutcheon, rendering the carinal nodes indistinct or only well defined near to the umbones.

A series of the Bracquegnies specimens, kindly forwarded to me by Dr. C. Barrois, of Lille, illustrates every stage of growth in the variety *confusa*. The few first-formed rows of costæ are plain and angulated or nearly destitute of nodes or tubercles,

excepting at the boundary of the escutcheon, where they form a carinal angularity; the escutcheon is well defined, and its surface equally, as in the area, is closely and profusely tuberculated. The ligamental cavity is larger and more lengthened than in the other form. Usually the rows of carinal nodes cannot be distinguished over the middle and posteal thirds of the valve, the entire surface of which is occupied by the large, crowded tubercles. This appears to be the only Belgian variety of *T. dædalea;* the convexity of the valves is greater than in the typical form, resulting from the greater breadth of the escutcheon.

With the foregoing species is associated another abundant and equally characteristic form, which in the Belgian beds seems to replace the *aliformis* group of Blackdown; this is the *Trigonia Elisæ* of Cornet and Briart. I am indebted to the liberality of Dr. Charles Barrois, of the Faculty of Sciences, Lille, for the gift of a series of each of these *Trigoniæ*. He refers them to the zone of *Am. inflatus*, Sow. *T. Elisæ* is a



Trigonia Elisæ, Cornet and Briart.

much ornamented and characteristic example of the *Scabræ*, allied to the *aliformis* group, and in common with others of its allies remarkable for the great length of the hinge-border and the shortness of the siphonal border; it is moderately convex anteally, produced and attenuated posteally. The rows of costæ covering the sides of the valves are very numerous and closely arranged, with rounded, depressed nodes; they are concentrically or obliquely arranged anteally; the rows rapidly diminish in size posteally, where their ornamentation becomes obscure. All the costæ have their posteal portions much attenuated, straight, perpendicular, or inclined retrally. The escutcheon is narrow and concave; it has delicate, closely placed, transverse costellæ, which also pass across the upper half of the narrow and flattened area, the lower half of which is smooth; there are no distinct carinal elevations, but the boundaries of the area and escutcheon are well defined.

TRIGONIA? MODESTA, *Tate*. Plate XLI, figs. 13, 13 *a*.

TRIGONIA MODESTA, *Tate and Blake*. 'The Yorkshire Lias,' *Lamellibranchiata*, by *R. Tate*, p. 386, pl. xiv, fig. 4, 1876.

The extension of the genus *Trigonia* to the *Armatus*-zone of the Lower Lias in Britain could only be accepted upon the clearest evidence, which unfortunately in the present instance is wanting. Entertaining doubts of the propriety of describing either of the two following minute specimens as examples of *Trigonia*, I have omitted to figure one of them, which in my opinion probably and apparently pertains to another genus of *Lamellibranchiata*.

The figure and description of *T. modesta* from the Yorkshire Lias as a British species compel the present notice.

The materials upon which it was endeavoured to found this species consisted of two very small, incomplete, and imperfect specimens, altogether insufficient for the purpose, obtained by Professor Tate in the *Ammonites-armatus*-zone of the Lower Lias of Warter and Robin Hood's Bays, North Yorkshire, and unfortunately no subsequent discovery of the shell has taken place. I am indebted to the courtesy of the Rev. J. F. Blake for the loan of these specimens.

It appears scarcely possible to convey information by any fair delineation of the little imperfect object upon our Plate; it may represent the very young condition of one of the *Trigoniæ Costatæ*, but even the genus is doubtful.

This ill-defined little shell, about $\frac{2}{10}$ths of an inch across the valve (the left), is in a soft shaly matrix; the test is ill preserved, and the apex has disappeared; the area, of which only the portion adjacent to the carina remains, is plain and somewhat concave; the marginal carina or posteal angle is distinct, plain, and slightly curved; the dorsal costæ are small, numerous, indistinct, and nearly horizontal; this apparently was the specimen which induced Professor Tate to give the name of *Trigonia modesta*. The small portion of the surface preserved posterior to the carinal angle is plain, a feature which militates against it being one of the *Trigoniæ Costatæ*.

Another specimen, of nearly similar dimensions, and attributed to the same species, appears to me to be distinct; it is in a fragment of hard, dark-coloured, shelly limestone from the same zone and locality; the test has disappeared, but the specimen generally is better preserved than the other; it represents an ovately oblong, moderately convex shell, of which the lower and posterior borders are not exposed, and the exact figure is therefore doubtful; the umbones have not much elevation, they are curved forwards, and placed anterior to the middle of the valve; the anterior border is produced and rounded; the posterior border is imperfect, it has a slightly defined carinal angle, and a narrow umbonal, smooth space posteal to it; the upper portion of the valve has a numerous series (about 12) of small dorsal costæ, which pass forwards from the posteal divisional angle and carina horizontally, and become evanescent about the middle of the valve; the anteal half of the valve is therefore without ornamentation. The anteal direction of the umbones appears to be sufficient to remove it from *Trigonia;* it must therefore remain one of the doubtful examples of the *Lamellibranchiata;* possibly it may be a *Corbula*. The posteal extremities of the few last formed costæ extend nearly to

the border of the valve, which there exhibits no appearance of a carinal area or escutcheon.

Genus—Myophoria. *Bronn*, 1835.

Before concluding the present Monograph I was tempted to depart so far from its scope and intention as to refer to a genus, and single British species, allied to *Trigonia*, and constituting its immediate precursor. *Myophoria*, a genus of *Conchifera* special to the Trias, established by Bronn in 1835, has been amply illustrated in his 'Lethæa Geognostica,' and by Goldfuss in his 'Petrefacta Germaniæ,' including several species of *Myophoria* from the Muschelkalk, which the latter author assigned to *Trigonia* (*Lyrodon*). In Germany and the Tyrol the *Myophoriæ* occur in the Hallstadt, the St.-Cassian, and the Kössen or Rhætic rocks, important fossiliferous formations, which in Britain are represented only by the Penarth beds, the highest stage of the Trias, and reduced considerably in thickness. At the base of the Lower Lias are certain brown sandstones, grey or greenish marls, black clays, and shales, with occasional limestone bands, having a thickness of from 30 to 100 feet, containing a very characteristic series of Rhætic fossils, more or less exposed at numerous localities, in the long course of the Lias between Somerset and North Yorkshire, probably extending uninterruptedly, but chiefly concealed in its course through the intervening counties.

The specimens of *Myophoria* herewith figured represent selected examples of the only recorded British species of that genus, obtained by my friend, Mr. C. Moore, in a bed of hard limestone one foot in thickness, called the "flinty bed of Bere Crowcombe," disclosed by a section made by a canal tunnel at an obscure locality near the town of Ilminster; the blocks of limestone also contained a considerable series of *Gasteropoda* and *Conchifera* included in Mr. Moore's collection of Rhætic fossils from the County of Somerset, described and figured by him in the Memoir subsequently cited.

Myophoria differs as a genus from *Trigonia* chiefly in the absence of transverse sulcations upon the diverging hinge-processes, and not less universally by the direction of the umbones, which, unlike those in *Trigoniæ*, are turned forwards as in the *Conchifera* generally.

Limited stratigraphically to the Trias, this genus of small Conchifers exhibits only a portion of that diversity of aspect, both in groups and species, found in its more important analogue *Trigonia*; the species may be arranged into three sectional divisions, succinctly described as follows:

The first group, trigonal in figure, has one, two, or three large costæ or varices diverging from the umbones, which for the most part disappear before reaching the lower border. Examples: *Myophoria vulgaris*, Bronn, 'Lethæa,' tab. xi, fig. 6; *Myophoria*

pes-anseris, Bronn, ibid., tab. xi, fig. 8; *Lyrodon Kefersteinii*, Münster, Goldf., 'Petrefacta,' tab. cxxxvi, fig. 2. There is nothing analogous to this section in the genus *Trigonia*.

The second group, for the most part also subtrigonal in figure, has the surface destitute of ornamentation, or has only longitudinal plications; it is without any clearly defined posteal area, or has an imperfect marginal angle. Examples: *Lyrodon ovatum*, Goldfuss, 'Petrefacta,' tab. cxxxv, fig. 11; *Lyrodon lævigatum*, Goldf., ibid., tab. cxxxv, fig. 12; also *Lyrodon simplex*, Goldf., ibid., tab. cxxxv, fig. 14. This group in its surface characters has affinities with some of the *Trigoniæ glabræ*, and more especially with *Trigonia Lingonensis*, Dum.

The third group has longitudinal costæ and a posteal area, which is separated from the other portion of the valve by a marginal carina; the area has also oblique costellæ; it thus approaches to the *Trigoniæ Costatæ* in various features, and more especially by the differences exhibited by the opposite valves of the same species; differences, however, which are wholly distinct from those exhibited by the Jurassic *Trigoniæ* of the allied section. The single British species *Myophoria postera* belongs to this third group. Other examples are *Lyrodon lineatum*, Münster, 'Petrefacta,' tab. cxxxvi, fig. 4; and *Myophoria Goldfussii*, Bronn, 'Lethæa,' tab. xi, fig. 7. This group is allied to the *Trigoniæ costatæ*, yet possesses an unerring distinctive feature; the Jurassic *Trigoniæ* have the marginal carina of the right valve larger than that of the other, and is never divided, as in the *Myophoriæ*, into two or three smaller carina, which cross the dorsal portion of the valve.

In venturing to propose the foregoing sectional divisions for *Myophoria*, I would offer them only as exemplifying the present knowledge of that genus, at the same time avowing the possibility that future discoveries in Triassic palæontology may tend to modify very materially the divisional groups here proposed.

MYOPHORIA POSTERA, *Quenst.*, sp. Pl. XLI, figs. 6, 7, 8, 9; 6 *a*, 7 *a*, 8 *a*, 9 *a*.

TRIGONIA POSTERA, *Quenstedt.* Der Jura, tab. i, figs. 3—6, p. 28, 1857.
MYOPHORIA — *Moore.* Quart. Journ. Geol. Soc., p. 507, pl. xvi, figs. 8, 9, 10, 1861.

Diagnostic Characters.—Shell very convex at the divisional angle of the valve, subtrigonal; umbones rather depressed, directed anteriorly, forming a buccal excavation anteally; the lower margin is lengthened and curved elliptically. The left valve has an elevated marginal carina, which is denticulated more or less prominently upon its lower half; it is bounded anteally by a strongly defined ante-carinal groove; there is no distinct median or inner carina. The area, which is steep and wide, has a series of

large, acutely ridged plications; they are somewhat irregular and unequal in their prominence, the surface becoming somewhat depressed at the position of the escutcheon, where the plications are smaller and less distinct; about eight or nine plications are visible upon the left valve; the hinge-border slopes obliquely downwards, its length exceeding that of the siphonal border, which is almost perpendicular with the lower border. The dorsal portion of the surface is covered by a series of linear, depressed, horizontal costæ; their size is unequal in different specimens and irregular, sometimes even upon the same valve; they do not enlarge posteally, and disappear in the ante-carinal groove; nearly fifty of these linear costæ may be distinguished. The right valve has its area somewhat more excavated; its plications are very irregular in prominence and unequal in size, but smaller and more numerous than those of the left valve; the marginal carina is smaller, it is plicated more or less distinctly upon its lower portion; its upper portion, which is smooth, divides into two carinæ, which continue separate and distinct to the lower border. There is also a third dorsal carina at a little distance anteally to the second carina, defined chiefly by the greater depression of the surface occupied by these three carinæ when compared with the general dorsal linear costæ of the right valve, which do not differ materially from those of the other valve.

The shell is of moderate thickness, even near the lower border. The mould does not exhibit any portion of the external ornamentation. Only single valves have been obtained, and the hinge-characters have not been exposed.

Height of the largest specimen 5 lines; length $5\frac{1}{2}$ lines.

The Bere specimens, in common with some Jurassic *Conchifera* having a hard limestone matrix, appear to have had their surfaces covered and their ornaments concealed by the infiltration of a layer of carbonate of lime between the outer surface of the fossil and its matrix. Small portions of this white film-like layer are still visible upon some of the specimens. I did not consider this exterior surface as having formed any portion of the test.

CONCLUDING SYNOPTICAL OBSERVATIONS.

During the period occupied by the publication of the earlier portions of this Monograph it was suggested to me upon more than one occasion by a palæontologist, since deceased, whose varied and extensive knowledge entitled his opinions upon such a subject to high consideration, that I should reconstruct the *Trigoniæ* by arranging them into a family, separating its species into from five to ten genera. The consideration of a similar proposal has probably occurred to other naturalists, and had, in fact, been present to my own mind during many previous years, and had induced me to bestow more than usual attention upon the various aspects assumed by the genus. The results of these observations had, however, tended in a direction the opposite of that proposed to me; they had led to the perception of a general resemblance between the several groups of species in features of sufficient importance to induce me to regard them as forming only so many portions of one great whole,—as so many allied forms greatly varied, which, whether viewed separately or in combination, constituted only a single generic idea, the subordinate features of which were elaborated, some synchronously, others in a certain order of geological succession, never occurring all together or in a single stratigraphical position. It therefore appeared to me that to regard certain differences between such groups as of generic value would be an attempt to dissociate forms which are by natural affinity in close relationship,—to do violence to the chain of life disclosed by an important genus through the great geological periods to which it belonged,—and not less an endeavour to dissolve the association which exists between the more ancient Mesozoic forms and the Tertiary and living portion of the genus which still remain to us.

As examples of such proposed reconstruction grounded upon differences of figures and of surface-ornaments, it would apparently become necessary to divide the extensive section of the *Scabræ* into three genera, one type form of which would have its representative in *T. spinosa*, Park., Plate XXIV; a second in *T. pennata*, Sow., Plate XXIV; the third in *T. aliformis*, Park., Plate XXV; species remarkably distinguished when separated from the *Trigoniæ* generally and brought together for comparison, in their general forms, their ornaments, and even to some extent in their internal hinge-characters, but which will be found to form a gradual approximation when they are compared through the connecting links of other examples of the *Scabræ*,—forms from which they can only possibly be as so many species.

The *Quadratæ* also, although they are sufficiently distinct in the more short or quadrate forms as *T. quadrata*, Ag., p. 105, and *T. spectabilis*, Sow., Plate XXVI, present in other examples approaches both to the groups *spinosa* and *aliformis* of the *Scabræ*.

Perhaps no sectional forms are usually more clearly separated than the *Glabræ* and the *Clavellatæ*, but certain Upper Jurassic species of the former section (see Plates XVIII, XIX, XXI) occasionally acquire much of the exterior ornaments of the *Clavellatæ;* this latter section and the *Scaphoideæ* can sometimes only be separated rather doubtfully, and a similar remark will also not unfrequently apply to the separation between the *Clavellatæ* and the *Undulatæ*. For illustrations of the *Undulatæ* see the figures in Plates XIII, XIV, XV, XVI, and XVII. Doubtless the group of the *Costatæ* possess the most strongly defined sectional characters, more especially in the posteal slope of the area and escutcheon, with the peculiarities of their carinæ and costellæ, together with the differences which they present in opposite valves of the same species; but even these features, so important in their combination, become in some instances modified or only slightly defined.

The proposed division of *Trigonia* into several separate genera is based upon the high value attributed to the exterior form and ornaments as examples of generic character, the internal and chiefly the hinge-characters being regarded as constituting features pertaining to a great natural family, embracing all the groups of species. The separation of the genus adopted in this Monograph is based upon the opposite principle,—that the internal characters are the only features which can be relied upon as affording decided distinctions more important than those of species or of subgenera, and that the modifications which embrace all the features connected with the external figure and surface ornaments are only of subordinate or sectional value, more or less linked together, and are chiefly of interest and importance in comparing the stratigraphic value or succession in geological time of these several features, and of affording separation between the several series of forms of which such groups are composed. The generic distinction based chiefly upon the hinge characters has the further advantage in the genus *Trigonia* of its great convenience in legislating upon the fossil internal moulds of *Conchifera*, which afford usually so few features supplying distinctive characters. It becomes of great importance to have upon the moulds indentations of any undoubted hinge characters distinct from all others, and such are supplied by the transverse sulcations upon both sides of the diverging hinge-processes in *Trigonia*, a feature which can always be recognised in well-preserved moulds and is free from ambiguity, and by which also its hinge is clearly separated from that of its allied genus *Myophoria*.

Upon contemplating the changes exhibited by the *Trigoniæ* during the long succession of Molluscan life disclosed by the two great Jurassic and Cretaceous portions of the Mesozoic æra, as developed both in Britain and over the continents generally, we observe a long, partially broken, imperfect chain of life, even the earlier portions of which seem, but as continuations of previously existing groups of allied organic forms; of these the more immediate precursor is the *Myophoria* of Bronn, an important genus of small Conchifers represented by numerous species, all of which are more or less allied to *Trigonia* and one group more especially to the section of the *Costatæ; Myophoria* is special to the

Trias, its species occur in France, Alsace, Hanover, Brandenburg, Saxony, Swabia, Wurtemberg, and the Tyrol. In Britain it is represented by a single species obtained only in one bed of the highest or Rhætic stage of the Trias, exemplified by *Myophoria postera*, Quenst., Jura., tab. i, figs. 3—6, discovered by Mr. Moore at an obscure locality in the county of Somerset. The anteal direction of the umbones serves effectually to separate it from the *Trigoniæ costatæ*, irrespective of the distinctions afforded by the hinge-processes.

The exterior ornaments in *Myophoria postera*, p. 215, are analogous to, but are altogether distinct from, the Jurassic *costatæ;* the opposite valves more especially offer important differences.

Throughout the several zones of Molluscan life disclosed by the Lower Lias the genus *Trigonia* is known only by one or two minute, imperfectly defined specimens, doubtful generically, obtained by Professor Tate in the *Armatus-zone*, and named by him *Trigonia modesta*, 'Yorkshire Lias,' p. 386, pl. xiv, fig. 4, depicted also of the natural size upon our Plate XLI, fig. 13: but in the absence of more satisfactory specimens the presence of this genus in the Lower Lias remains doubtful.

The Middle Lias of France has produced rather abundantly, and that of Britain very rarely, and apparently localised in each country, a single species of the *Trigoniæ glabræ*, *T. Lingonensis*, Dum. (Plate XXII), p. 98, an abnormal form when compared with the genus generally, almost devoid of surface ornaments, and in that feature approaching to a group of the more ancient Triassic *Myophoria*, but even in this exceptional species the figure agrees with that of the genus subsequently developed; the umbones, unlike those of *Myophoriæ*, are recurved or directed backwards, thus departing both from the figure of that genus and from the *Conchiferæ* generally, but agreeing with the *Trigoniæ*, and imparting a degree of concavity both to the area and escutcheon. *T. Lingonensis* is limited to the main ironstone band of the Zone of *Ammonites spinatus*, both in France and in Yorkshire.

Since the notice of the discovery of this species in Yorkshire by Professor Tate in 1872, English geologists working upon the long course of the Middle Lias have searched for this remarkable *Trigonia* in the midland and southern counties of England without success with one exception, in which several specimens were obtained in the *Spinatus*-zone in the vicinity of Banbury by Mr. E. A. Walford of that place during the past summer of 1877; the same gentleman has also forwarded to me an internal mould of *Trigonia* obtained by him in the Zone of *Ammonites Henleyi* in the same vicinity; it is not certain to what species it belongs, apparently it does not differ materially from moulds of *T. Lingonensis;* in either case it establishes the presence of the genus Trigonia in a lower zone of the Middle Lias.

In the Cleveland Ironstones this species continues to be one of its most rare forms, notwithstanding that the bed has been extensively worked and its fossils diligently collected at numerous localities over wide areas and during many years.

In the Upper Lias and Supra-liassic Sands of Britain the usual Jurassic sectional forms of *Trigonia*, consisting of the *Costatæ*, *Clavellatæ*, and *Undulatæ*, already acquired some of the importance and variety by which they were subsequently characterised.

In the *Costatæ* are surface ornaments and some other external features observed in the *Myophoriæ*, but the umbones are never directed forwards as in that genus, and the hinge-processes present differences, both in their figures and in their deeply sculptured sulcations, which are not limited to one side only of each process; the right valve presents the more important differences, the marginal carina is not divided into two or three costellæ as in *Myophoria*, but forms a single carina larger than that of the left valve; the costellæ upon the area are also fewer and larger than those of the other valve. The Lower Oolitic rocks abound with this important sectional form, which in Britain is represented by upwards of twelve species besides varieties; abundant and dwarfed in the oolitic limestones of the Inferior and Great Oolite, they acquire large dimensions in the clays and argillaceous shales. The stratigraphical range of the section *Costatæ* is not considerable, ten of the British species occur only in the Lower Oolites; one of these, *T. hemisphærica*, and its variety named *gregaria*, Plates XXXI and XXXIII, although distinct generically from *Myophoria*, yet has some external resemblance to *Myophoria lineata*, Munst., and to *M. postera*, Quenst.; the variable and minute longitudinal costæ are more especially analogous. The British Upper Oolites have only two additional species of the *Costatæ* special to those stages. These are *T. Meriani*, Ag., and *T. monilifera*, Ag., so that we have no example higher than the Kimmeridge Clay; and even *T. monilifera* (Plate XXXI), locally so abundant in the lower beds of that stage, is but a continuation of the same form which occurs more rarely in the beds of Upper Calcareous Grit. The *Costatæ* occur apparently in greater variety in the Upper Jurassic rocks of France, Germany, and Switzerland. Only a minority of these have been figured and described: probably more than twice the number of ascertained species would be required to make up the sum of the European *Costatæ*. All of them disappear with the lower portion of the Portland formation.

Two abnormal costated forms occur in the Neocomian period if, indeed, we should include with that section *T. carinata*, Ag., and *T. peninsularis*, Coq., species which were deprived of the surface ornaments ere they attained adult growth, when one, and perhaps each of them, acquired a byssal aperture. *T. carinata* is always recognised by the great obliquity of the costæ; *T. peninsularis* has the costæ very irregular, imperfect in the rows, subangulated, and almost evanescent. In the distinctions between the opposite valves of the *Costatæ* described at p. 9, we see reproduced, modified, and less strongly defined some of the generic features of the *Myophoriæ* fading out, it may be, and modified upon the *Trigoniæ*. The variability in the number and size of the longitudinal costæ described as marking *varieties* of species in this Monograph were also produced as a variable feature in the more ancient *Myophoria postera*, of the Upper Trias; it is equally present in the Neocomian *T. carinata*, where the variability is so considerable as to induce Agassiz to

separate it into two species, the one with the few and large costæ constituting his *T. sulcata* ('Trigoniæ,' p. 44). Possibly *T. peninsularis* may be equally variable, but unfortunately Coquand has given only a single figure and of the left valve only ('Terr. Aptien d'Espagn.,' pl. xxiii, fig. 3).

However clearly separated are the *Costatæ* as a section, they also approach a very different section (that of the *Glabræ*) in certain Swabian species which have the middle portion of the valve entirely destitute of surface ornaments, as in *T. zonata*, Ag., *T. interlævigata*, Quenst., and *T. triangularis*, Goldf. They also approach to the *Clavellatæ* in *T. hybrida*, Roem., and in *T. geographica*, Ag., and in two less known forms alluded to at p. 161 under the names of *T. fimbriata*, Lyc., and *T. granigera*, Cont., which have the longitudinal costæ and also the plications upon the marginal carina minutely clavellated.

The *Clavellatæ* are peculiarly varied in species and locally abundant in the Middle and Upper Oolitic Rocks of Britain, numbering upwards of thirty-three species; probably they are not less abundant in France, Switzerland, and Germany, where, in the Oxfordian and Kimmeridgian stages, they appear to attain their maximum of numbers, and then suddenly disappear.

The *Undulatæ* are exclusively Jurassic, and little less varied than the *Clavellatæ*. Britain has twenty species. They occur in the Upper Lias, in the Supra-liassic Sands, and more abundantly in the Lower Oolites; locally they are gregarious. In the Middle and Upper Oolites they are much less conspicuous, and are represented by four species only. *T. pauricosta* alone can be said to be even locally abundant. They disappear altogether in the lower portion of the Portland formation.

The *Scaphoideæ*, comparatively a small section, occurs only locally, and of few species, chiefly in the Upper Lias and Inferior Oolite, after which nothing more is known of the section until it reappears in the Lower Calcareous Grit of Yorkshire, and, after another stratigraphical interval, widely separated, in the Middle Neocomian beds of Norfolk, where it is represented by two species, one of which, *T. exultata*, nob., Plate XXXVIII, is of gigantic dimensions. In the higher assemblages of Cretaceous fossils the *Scaphoideæ* are unknown.

The *Glabræ* in the circumstances under which they occur offer a marked contrast to the leading sectional forms of the genus both Jurassic and Cretaceous: belonging to the whole of the Mesozoic Epoch, it is only in the Portlandian beds of Britain that they become predominating forms; their occurrence as a single species dates from the earliest record of the genus in the Middle Lias above referred to. In the Inferior Oolite they are represented by the rare, anomalous, and in some respects almost unique, *T. Buvignana*, after which nothing more is known of the section until its reappearance in the Portland formation, represented in Britain by five species, two of which, *T. gibbosa* and *T. Damoniana*, occur in great abundance. All of these Portlandian *Glabræ* have a considerable family resemblance in their short, subglobose, or ovately rounded forms; their surface ornaments consisting for the most part of small, longitudinal, subtuber-

culated costæ; the plain antecarinal space is always well developed, and is usually the only smooth portion of the shell. The variability assumed by the three species *T. gibbosa*, *T. Damoniana*, and *T. Manseli*, in their surface-ornaments, are so considerable (exemplified on our Plates XVIII, XIX, and XXI) as to offer a remarkable contrast to other examples of the *Glabræ*, and surpass in diversity, perhaps, any other of the more ornamented examples of the genus. *T. gibbosa*, more especially, which I have arranged in three varieties, becomes in one of them a shell almost devoid of ornament, and is chiefly remarkable for the prominence of its zonal sulcations; in other forms its surface is crowded by its excentric costæ, and roughened by their small prominent tubercles.

The Isle of Portland, Tisbury, Warminster, Brill, and Swindon are the localities at which the *Trigoniæ Glabræ* are the predominating forms, the other sectional examples of the genus having altogether disappeared. The European continental *Glabræ* of the same period are *T. Michellotti*, De Lor. and Pellat, 'Boulogne,' pl. vii, fig. 6; *T. variegata*, Credner, 'Ob. Jura,' pl. viii, fig. 22, also a variety of the latter from Boulogne figured by De Loriol and Pellat, pl. xi, fig. 9. The latter species has the posteal portions of its costæ broken, forming lengthened oblong nodes, unlike the British species which are all tuberculated; *T. Boulogniensis*, De Lor. and Pel. 'Boulogne,' pl. vii, fig. 10, has irregular plicated costæ, destitute of tubercles, and has no zonal sulcations.

Of the seventy-eight species of Jurassic *Trigoniæ*, exclusive of varieties, found in Britain, and recorded in this Monograph, twenty-eight are also obtained at various European continental localities, but chiefly in France and Switzerland; six of these also occur in Southern Germany, and one species (*T. triquetra*, Sub.), Plates VI and XXXVI, in Northern Germany.

The general European assemblage of Jurassic *Trigoniæ* contained in the British Museum are so considerable, varied, and abundant, and their state of preservation so exceptionally fine, that it becomes a subject of regret so small a portion of them should come under the observation of the public; eventually this defect will be removed and a series of *Trigoniæ* disclosed, so remarkable and attractive that it may confidently be predicted they will engage the special attention of future palæontologists. The prevailing forms belong to the *Clavellatæ*, *Undulatæ*, and *Costatæ*, only a minority of which can be identified with recorded species.

Other European Jurassic Trigoniæ, not British, figured and described, are:

Trigonia costata, Chap. et Duv. Foss. de Luxemb., tab. 25, figs. 6, 7.
— *costata*, var. *triangularis*, Goldf. Petref., tab. 137, fig. 3.
— *similis*, Ag. Trig., tab. 2, figs. 18—21.
— *navis*, Lam. Ag. Trig., tab. 1, 2, figs. 21—24.
— *costellata*, Ag. Trig., tab. 2, figs. 1—12.
— *Bronnii*, Ag. Trig., tab. 5, fig. 19.
— *maxima*, Ag. Trig., tab. 4, figs. 6—9.
— *Golfussii*, Ag. Trig., p. 31.

Trigonia notata, Ag. Trig., tab. 5, figs, 1—3.
— *reticulata*, Ag. Trig., tab. 11, fig. 10.
— *parvula*, Ag. Trig., tab. 11, fig. 8.
— *rostrum*, Ag. Trig., tab. 9, fig. 1, tab. 5, fig. 10.
— *concentrica*, Ag. Trig., tab. 6, fig. 10.
— *picta*, Ag. Trig., tab. 6, fig. 11.
— *Parkinsoni*, Ag. Trig., tab. 10, fig. 6.
— *suprajurensis*, Ag. Trig., tab. 5. figs. 1—6.
— *truncata*, Ag. Trig., tab. 5, figs. 7—9.
— *clathrata*, Ag. Trig., tab. 9, fig. 9.
— *sexcostata*, Roemer, Nord. Ool., tab. 6, fig. 1.
— *inflata*, Roemer, Nord. Ool., tab. 19, fig. 22.
— *hybrida*, Roemer, Nord. Ool., tab. 6, fig. 1.
— *cardissa*, Ag. Trig., tab. 11, fig. 4.
— *concinna*, Roemer, Nord. Ool., tab. 19, fig. 21.
— *Bouchardi*, Oppel, Juraform., p. 486.
— *aspera*, Lam. Héb. Jour. de Conchyl., tab. 7, fig. 3.
— *inter-lævigata*, Quenst. Jura, tab. 67, figs. 7, 8.
— *Barrensis*, Buvig. Meuse Atlas, tab. 16, figs. 30, 32.
— *Arduennea*, Buvig. Meuse Atlas, tab. 4, figs. 10—14.
— *Kurri*, Opp. Juraform., p. 485.
— *variegata*, Credner, Ob. Jura, tab. 8, fig. 22.
— *verrucosa*, Cred., Ob. Jura, tab. 8, fig. 23.
— *clivosa*, Cred., Ob. Jura, tab. 9, fig. 24.
— *Boulogniensis*, D'Lor., Kim. of Boulogne, tab. 7, fig. 10.
— *Rigauxiana*, Mun. Chal., Bull. Soc. Lin. de Normandie, vol. 9, tab. IV, fig. 2.
— *Baylei*, Dolf. Kimmer., tab. 10, fig. 4.
— *granigera*, Contejean, Ét. Kimmer. de Montbeliard, tab. 14, fig. 4.
— *pseudo-cyprina*, Cont. Montbeliard, tab. 14, fig. 7.
— *trigona*, Waagen, Beitr., tab. 29, fig. 3.
— *Etalloni*, de Loriol, Royer et Tombeck, Ét. Jur. Sup. Haut. Marne, tab. 17, figs. 7—10.
— *spinifera*, De L., R., et T., tab. 18, fig. 2.
— *Cottaldi*, Mun., De L., R., et T., tab. 17, fig. 3.
— *Tombecki*, De L., R., et T. tab. 18, fig. 21.
— *Matronensis*, De L., R., et T., tab. 18, fig. 24.
— *Carmontensis*, De L., R., et T., tab. 17, figs 10, 11.
— *Moutierensis*, Lyc. Monogr. Trigoniæ, p. 36.
— *Michellotti*, D'Lor. et Pellat, Boulogne, tab. 7, fig. 6.

Our notices of the Jurassic *Trigoniæ* of the other continents must be understood as relating chiefly to their natural affinities as species, and not to their stratigraphical positions, which, in some instances, are only doubtfully and imperfectly known.

We are absolutely without information of the presence of a single Jurassic *Trigonia* in the continents of America. In Asia one of the *Undulatæ* occurs in the mountain district of the Lebanon, to the eastward of the town of Beyroot; apparently it is identical with *T. undulata*, Fromherz, from the Piedmontese flanks of the Alps (p. 77) and nearly allied to a *Trigonia* of the Cornbrash and Great Oolite in Britain (p. 201).

In Cutch three of the *Costatæ* have been obtained, two of which nearly resemble *T. costata*, Sow., and *T. pullus*, Sow., British species of the Middle and Lower Oolites, and are so named 'Geol. Trans.,' 2nd ser., vol. v, pls. 21—23; the third, a large, lengthened, and oblong form, distinct from all others, is named by Sowerby *T. Smeeii*, 'Geol. Trans.,' 2nd ser., vol. V, pl. 61. The Ammonites associated with these species are, for the most part, identical with British Kelloway Rock forms.

In Northern India the Spiti Pass of the Himalayas affords a fossil Jurassic fauna, which Dr. Stoliczka has assigned to certain *Conchifera* of the European Rhætic beds, Lias, and Lower Oolites, *Trigonia costata* is one of these, 'Quart. Jour. Geol. Soc.,' 1868, p. 506, vol. xxiv.

The only record we possess of Jurassic *Trigoniæ* in Australia is the memoir on Australian Mesozoic Geology and Palæontology, 'Quart. Jour. Geol. Soc.,' May, 1870, by Mr. C, Moore, who has therein figured and described two considerable series of fossils from Queensland, and from Western Australia upon the opposite sides of Australia, separated by upwards of 38° of longitude, and by the great central Sahara. The West Australian series contains Ammonites, Conchifera, and Brachiopoda, some of which cannot be distinguished from British species of the Middle Lias, Upper Lias, and Lower Oolites, including *Trigonia Moorei*, Lyc. (p. 151), which occurs in some abundance, a single block having contained fifteen specimens. The Queensland fossils from Wollumbilla and other localities are almost entirely distinct from known European forms: they are preserved in loose blocks evidently derived from beds more ancient than the surrounding strata; numerous in species, two only are believed to be identical with European shells: one is *Avicula Braamburiensis*, a species which has a considerable stratigraphical range in Britain, and is so nearly allied to other forms of the same genus that great care and an excellent condition of preservation are necessary in its discrimination; the other is *Lingula ovalis*, which differs little from the *L. subovalis* of Neocomian strata. Mr. Moore has described and figured *Trigonia lineata*, pl. 13, fig. 12, an ill-preserved fossil, one of the *Glabræ*, a short, gibbose form, with numerous concentric regular lines upon the anteal and middle portion of the shell, but the posteal or anal portion is imperfect; it has some affinities with the Portlandian group of *T. gibbosa*, and is apparently yet more nearly allied to an Indian Cretaceous species, *T. orientalis* or *suborbicularis*, Forbes, from Southern India (see page 121); the latter has the concentric

lines much more prominent than in *T. lineata;* the posteal slope is destitute of bounding carinæ. The presence of a gigantic *Crioceras* at the same locality is also strongly indicative of the Cretaceous rocks.

It is evident that further explorations and collections of fossils, and more especially of *T. lineata*, will be required ere the stratigraphical position of the Queensland beds can be determined without ambiguity.

On passing from the Jurassic to the Cretaceous rocks the genus *Trigonia* presents some very remarkable changes; the large and conspicuous section of the *Undulatæ* is found to have altogether disappeared, neither is there known a single continental example of the *Clavellatæ*.

In the Neocomian period generally the great sectional series of *Trigoniæ*, constituting the *Scabræ* and *Quadratæ*, first appear, replacing the lost *Costatæ*, *Clavellatæ*, and *Undulatæ*. Varied in species, considerable in numbers, and conspicuous beyond all other sectional forms in their ornaments and in their individualisation, they continue prominent and generally predominating in every considerable assemblage of *Conchifera* throughout the varied beds of the Cretaceous rocks in whatever country they are discovered, so that *a clavellated Trigonia having an ornamented escutcheon becomes an infallible indication of the presence of the Cretaceous rocks.* The converse of this statement holds good as to the clavellated species with smooth escutcheons; they are all Jurassic. The two examples figured in this Monograph, *T. ingens*, Lyc., Pl. VIII, figs. 1—3, and Pl. XXXVI, figs. 5, 6; and *F. Keepingi*, Lyc., Pl. XXXV, figs. 1, 2, are the only known Cretaceous *Clavellatæ*. They have been obtained only within the very limited area occupied by the Middle Neocomian formation in Britain.

It is in the Cretaceous *Trigoniæ* also that we find the genus represented by the greatest variety of figure, ranging from the short, suborbicular, or subquadrate examples of the *Quadratæ* to the subcrescentic attenuated forms of a portion of the *Scabræ* or group of *T. aliformis*, the latter having their siphonal borders so short that the incurrent and excurrent respiratory orifices are brought into near proximity. They differ likewise from all other of the Mesozoic *Trigoniæ* in having the lower borders of the valves toothed, a feature which is reproduced in the living Australian section of the *Pectinidæ*. These differences of figure are so considerable that when they are found to apply to the vital organs it can scarcely be supposed that the Mollusca so differently constituted could have had the same habitats in depths of waters, or that their characteristic habits were similar. Nevertheless, throughout the Trigonia-bearing beds of the Cretaceous rocks, from the Middle Neocomian beds even to the highest beds of Chloritic Marls, we find these forms so dissimilar associated, their valves sometimes together, but more frequently separated, leading to the inference that the dead Testacea were in some instances drifted to the places where they are found in such considerable numbers.

The Cretaceous *Quadratæ* also possess a peculiar feature which must have a connection with the general economy of the Mollusk. The hinge-processes, even in the

largest examples of that section, are remarkably small, but the valves have internally near the middle of the lower border, and external to the pallial scar, a few closely placed oblong pits, apparently intended to afford attachment to an accessory ligamental appendage, enabling the Mollusk to hold the valves closed with greater power. As these pits existed at several stages of growth, it is evident that they were reproduced periodically, and were obliterated at each period by the growth of new shell-substance (for examples of this feature see Pl. XXIV). The *Quadratæ*, also, had their hinge-plates strengthened by additional ligamentary support at the posteal extremity of the plate, which has several oblique grooves, a feature which also obtains in the *aliformis* group of the *Scabræ*, but is not seen in any other section of the genus.

The Blackdown and Haldon Greensands are represented in Belgium by the *Meule de Bracquegnies*, in which those beds reappear both lithologically and palæontologically; the *Trigoniæ* are, however, for the most part distinct in species. The Belgian *T. dædalea* differs from the well-known form of Blackdown, but is identical with our variety *confusa*, Pl. XXIII, fig. 1, which in Britain occurs rarely, at Little Haldon, much to the westward of the typical form; it is abundant at Bracquegnies, as is also *T. Elisæ*, one of the *aliformis* group special to that locality (Cornet and Briart, 'Acad. Roy. de Belgique,' t. xxxiv).

The *Trigoniæ*, so abundant in the Cretaceous glauconitic sands and marls, disappear suddenly and entirely with the advent of the Chalk. Apparently this change is not an exceptional feature as regards the *Trigoniæ*, but is connected with a similar loss of genera in other Dimyarian *Conchifera*, a circumstance which becomes remarkable when compared with the general abundance and variety of Monomyarian forms in the same deposits; a fact which has long been observed, but which has not hitherto received a satisfactory explanation.

The only record we have of the genus *Trigonia* in the White Chalk consists of some impressions, ill preserved, named by d'Orbigny *Trigonia inornata*, 'Pal. Fran. Terr. Crét.,' pl. 297, from Royan, Charente Inférieure, a moderately convex, subovate shell, having apparently a plain area and escutcheon, and a numerous closely arranged series of obliquely curved costæ (about forty) covering the other portion of the shell, passing from the angle of the valve to the anteal and lower borders, but so faintly traced that the entire surface appears almost devoid of ornamentation; thus approximating or apparently intermediate to, the *Scabræ* and *Glabræ*.

The Cretaceous *Trigoniæ* are, for the most part, localised; of the thirty-one species yielded by the British rocks fourteen only have been identified at continental localities, and limited to neighbouring countries, as France, Belgium, Switzerland, Southern Germany, and the Spanish Peninsula. A considerable proportion of the French Cretaceous *Trigoniæ* appear also to be special to that country.

The Aptian beds of Spain, Province of Teruel (Coquand, 'Monogr. de l'étage Aptien de l'Espagne'), appear to have been deposited in a portion of a Mediterranean

basin of the Lower Cretaceous period ; their *Trigoniæ* are for the most part special to them ; *T. peninsularis*, Coq., is an abnormal example of the *Costatæ ; T. Picteti*, Coq., and *T. abrupta*, Coq., belong the *Scabræ ; T. Hondeana*, Coq., to the *Quadratæ*. Neither of the two latter forms will allow of any close comparison with the South American species from the equatorial region, to which the same names had previously been given by Lea and by Von Buch. Their localisation is as distinct as that of the British Upper Neocomian *Trigoniæ*.

The Spanish *T. abrupta* is nearly allied to a small British *Trigoniæ* from the Chloritic Marls of South Devon (see *T Meyeri*, p. 125, Pl. XXIII ; also Pl. XLI, figs. 15, 16). The two very dissimilar figures given of the American species in the works of Von Buch and D'Orbigny will, perhaps, account for this supposed identity between the American and Spanish species.

From near the western coast of the same peninsula, in the vicinity of Torres Vedras, a series of Testacea has been described and figured by Mr. D. Sharpe ('Quart. Jour. Geol. Soc.,' vol. vi, pls. 20—24, and referred to the Subcretaceous, or lower portion of the Cretaceous rocks. Among them is *Trigoniæ Lusitanica*, Sharpe, a characteristic example of the *Scabræ*, previously figured by Goldfuss, together with three other *Trigoniæ*, all of which the latter author erroneously referred to the *T. literata* of Young and Bird and of Phillips. The Neocomian *T. caudata*, Ag., is also associated with *T. Lusitanica*.

Other Cretaceous European *Trigoniæ*, not British, already figured, are :

Trigonia disparilis, d'Orb. Terr. Crét., 3, pl. 299, fig. 2.
— *limbata*, d'Orb. Terr. Crét., 3, pl. 298.
— *Lamarkii*, Matheron. Catal., pl. 24, figs. 5—7.
— *tenuisulcata*, Dujard. Mém. Soc. Géol. Fr., t. 2, pl. 15, fig. 14.
— *excentrica*, Goldf. Petref., 3, pl. 137.
— *pulchella*, Reuss. Bohem., pl. 41, fig. 3.
— *scabra*, Lam., d'Orb. Terr. Crét., pl. 296.
— *Coquandiana*, d'Orb. Terr. Crét., 3, pl. 294.
— *crenulata*, Lam., d'Orb. Terr. Crét., 3, pl. 295.
— *divaricata*, d'Orb. Terr. Crét., 3, pl. 288, figs. 2—4.
— *longa*, Ag. Trigon., pl. 8, fig. 1.
— *Robinaldina*, d'Orb. Terr. Crét., 3, pl. 299, figs. 1, 2.
— *paradoxa*, Ag. Trigon., pl. 10, figs. 12, 13.
— *Delafossei*, Leymerie. Mém. Soc. Géol. Fr., 2 ser., t. 4, pl. 8.
— *Constantii*, d'Orb. Terr. Crét., pl. 291, figs. 3, 4, vol. 3.
— *palmata*, Desh. Mém. Soc. Géol. Fr., vol. 5, pl. 8, fig. 5.
— *nodosa*, Pictet and Roux. Grés Verts, pl. 35, fig. 5.
— *sanctæ-crucis*, Pictet. Paléont. Suisse, pl. 128, figs. 2—5.
— *nodosa*, Pictet. Paléont. Suisse, pl. 12, figs. 1, 2.
— *Elisæ*, Cornet and Briart. Meule de Brecq., pl. 6, figs. 4, 5.

In Britain the Cretaceous *Trigoniæ* constitute portions of four well-marked zoological assemblages, separated in stratigraphical position; they assist materially in imparting a characteristic *facies* to each series. Of the Middle Neocomian *Trigoniæ*, six in number, one only of the *Quadratæ*, *T. nodosa*, constitutes a variety of a species which in the Upper Neocomian beds is represented by other forms.

Of the others, two belong to the *Clavellatæ*, and have a Jurassic aspect so remarkable that one of them, *T. ingens*, Lyc. (Pl. VIII, figs. 1, 2, 3; Pl. XXXVI, figs. 5, 6), might readily be mistaken for the *T. signata* of the Inferior Oolite; the other species, *T. Keepingi*, Lyc. (Pl. XXXV, figs. 1, 2), with a shorter figure, has an aspect equally Jurassic. In the absence of all knowledge of their position and associated fossils they would undoubtedly have been assigned to the more ancient period. The Upper Neocomian formation is represented by seven *Trigoniæ*, of which one (*T. nodusa*, Sow.) is a variety of the Middle Neocomian form; a second (*T. carinata*, Ag.) passes upwards into a higher stage; the other five species are all *Scabræ*, and are special to that stage. The third, or stage of the Blackdown and Haldon Greensands and Gault (identical also with the Belgian *Meule de Bracquenies*), has nine ascertained species, including two of the *Quadratæ*, viz. *T. dædalea*, Park., and *T. spectabilis*, Sow., two of the *Glabræ*, *T. excentrica*, Park., and *T. læviuscula*, Lyc., and five of the *Scabræ*. There is also an internal mould in the Red Chalk or Gault of Hunstanton not sufficiently characterised. The fourth or highest stage, consisting of Upper Greensand and Chloritic Marls, has upwards of sixteen species; and three others have been observed by Mr. Meÿer in the hard rocks and marly beds of the South Devon Coast, which hitherto he has not been able to add to his collection. Of the sixteen, three are varieties of forms met with in the third series, as *T. aliformis*, *T. spinosa*, and *T. Vicaryana;* three others which have passed upwards without apparent change, as *T. scabricula*, *T. læviuscula*, *T. spectabilis*, and *T. carinata;* leaving ten other species apparently special to the highest stage.

D'Orbigny assigned the maximum development of the genus *Trigonia* to the highest fossiliferous beds of the Cretaceous rocks (*Cours élément. de paléont.*, Tableau 8). In Britain our stratigraphical table records the greatest number of species in the Lower Mesozoic rocks or Inferior Oolite, and in the Upper Greensand and Chloritic Marls of Wilts and of the Isle of Wight. The hard rocks in the cliffs of the South Devon Coast have also produced *Trigoniæ*, for the most part in a very ill state of preservation; and great difficulty is experienced in procuring useful and reliable specimens. Enough, however, is ascertained to assure us that the genus was represented in Britain at this the period of its final disappearance in a manner both ample and varied. For these the reader is referred to the stratigraphical table, also to the figures on Plates 23, 24, 25, 26, 28, 35, 37, 40, and 41.

The Cretaceous *Trigoniæ* obtained in the American continent, although not numerous in species, are not less remarkable and well characterised. With the exception of a single lengthened species of the *Glabræ* from Columbia (*T. Lajoyei*, d'Orb.), all pertain to

to the *Scabræ* and *Quadratæ*, *T. Thoracica*, Mor. ('Synopsis,' pl. xv, fig. 13), from the State of New Jersey and from Alabama, is allied to the *Aliformis* group. To the same group is also allied a large and abundant Mexican species, *T. plicato-costata*, figured and described by Nyst and Galeotti ('Bull. l'Acad. de Bruxelles,' tom. vii, No. 10), from the great principal Cordillera of Anahauc, Mexico, several thousands of feet above the sea. This species, which was erroneously referred by the authors to the Jurassic rocks, has a near ally in our *T. scabricola*. *T. Humboldtii*, von Buch ('Petref. Americ.,' figs. 29, 30), another of the *Scabræ*, has radiating costellæ passing from the umbones retrally over the upper and siphonal half of the shell; its locality is San Felipe, Central America.

In the elevated region of equatorial South America, in New Granada and Columbia, the same groups are represented by several unusually large and remarkable species. *T. abrupta*, von Buch ('Petref. Amer.,' fig. 21), an ovately oblong form, with numerous delicate, almost evanescent, straight, oblique, retral or nearly perpendicular, minutely crenulated costæ; the area and escutcheon, which have considerable breadth, are almost plain. Also a large species named *T. aliformis*, by von Buch ('Petref. Amer.,' fig. 10), which may be a more fully developed example of *T. thoracica*, Mor. Another is *T. subcrenulata*, d'Orb. ('Coq. Foss. de Colomb.,' pl. iv, figs. 7, 8), a remarkably inflated subcrescentic shell, allied to *T. crenulata*, Lam., in the general features of its ornamentation, distinguished by its more inflated and lengthened form, by the small and deep concavity formed by the indistinctly separated area and escutcheon, by the zigzag costellæ of their transverse ornaments, and by the small, perpendicular, widely separated crenulated rows of costæ. Another is a gigantic example of the *Quadratæ* from Bogota, *T. Hondeana*, Lea, *T. Boussignaultii* (d'Orbigny, 'Coquilles fossiles de Colombie,' pl. iv, figs. 1, 2), distinguished by the gigantic size, by the extreme shortness of the general figure, by the few perpendicular rows of small, widely separated, crenulated costæ, and by the great breadth of the area and escutcheon, whose transverse, curved costellæ agree with the ornaments upon the other portion of the shell; the umbones are obtuse, and the borders of the valves are rounded.

Not less distinct and well characterised are the prevailing Trigoniæ of the South African provinces to the eastward of the Cape of Good Hope; these belong to two very different stages of the Cretaceous formations. That of the province of Uitenhage has been investigated and illustrated by Dr. Krauss, of Stuttgart, by Dr. Rubidge, and Dr. Atherstone, who assigned them to the Cretaceous rocks. The fossils from the same beds have been examined by Mr. D. Sharpe and Professor R. Tate, and the opinion of these two palæontologists, founded upon the analogies of the fossils generally, was that they were Jurassic and should be referred to the Lower Oolites. In offering an opinion adverse to the latter conclusion, I would admit the Jurassic aspect of some of the Conchifera, which, in common with certain European forms, indicate that the *Jurassic facies* did not disappear suddenly and entirely with the close of the Jurassic

period, but was in some instances continued partially into the Molluscan fauna of the lower portion of the Cretaceous rocks. Notwithstanding, however, certain specific resemblances, I doubt the absolute identity of any one of these African species with European allied forms. The occurrence of *T. Herzogii*, Haussman, of *T. conocardiiformis*, Krauss (p. 210), and of *T. ventricosa*, Krauss (p. 119), in such profuse numbers and distributed over so wide a region, the first a member of the *Quadratæ*, the others of the *Scabræ*, may, in the absence of reliable and guiding Ammonites, be regarded as affording strong, and to my mind, decisive evidence of the Cretaceous character of the series. The resemblance (perhaps even identity) of *T. ventricosa* with the Indian Cretaceous *T. tuberculifera*, Stol. ('Mem. Geol. Surv. India,' vol. iii, pl 15), tends materially to support the same conclusion.

Two other Trigoniæ, mentioned in Professor Tate's memoir, require notice. Pl. 7, fig. 6, of that memoir represents the magnified figure of a very young Trigonia, which is attributed to *T. Goldfussi*, Ag. This, in common with other very young shells, might possibly pertain to one of the *Quadratæ*, and is even allied to certain young specimens of *T. dædalea*, Park. The other Trigonia mentioned is a single valve of one of the *Costatæ*, believed to represent a young specimen of *T. Cassiope*, d'Orb. (see Pl. XXXII). There can be no doubt of the importance which attaches to the presence of the *Costatæ* when the age of the stage is a question of doubt, but the presence of a single specimen cannot be accepted as affording any decisive proof in such a question.

The second, and apparently newer series of Cretaceous fossils, collected in the region of the Umptafuna and Umzanbani rivers, contains *T. elegans*, Baily, a small and much ornamented example of the *Scabræ* ('Quart. Jour. Geol. Soc.,' vol. xi, plate 13, figs. 3 *a*, *b*).

In Asia the Cretaceous Trigoniæ are scarcely known beyond the limits of the British Indian Empire. In the southern region, near to Pondicherry, two short subglobose species of the *Glabræ* have been figured and described by Forbes ('Geol. Trans.,' 1846, vol. vii, p. 150, pl. 18) under the names of *T. semiculta*, *T. orientalis*, and *T. suborbicularis*. The first of these species has the longitudinal costæ interrupted about the middle of the shell by the usual smooth antecarinal space; the other two, which I can only regard as varieties of one species, have the costæ, which are unusually prominent, continued without interruption across the whole surface; the area and escutcheon are only slightly developed. The last-named form has the costæ less prominent. They have some general resemblance to the *Glabræ* of the Jurassic Portland group, but differing in having their costæ entirely devoid of tubercles.

A small species of the *Scabræ*, *T. Forbesii* (p. 122), is also distinct from European forms. The Geological Survey of India has added but few additional Trigoniæ. *T. tuberculifera*, Stol., an inflated example of the *Aliformis* group, presents in its surface-ornaments varied aspects in its numerous specimens, which are altogether analogous to those assumed by its near ally the *T. ventricosa*, Kr., of Southern Africa, a considerable and instructive series of which are in the British Museum. Another small form of the *Glabræ*, *T. indica*,

Stol., and two others of the *Scabræ*, equally insignificant, *T. crenifera*, Stol., and *T. minuta*, Stol., complete the list of Indian Cretaceous Trigoniæ.

The section *Pectinidæ* was established by Agassiz in 1840 ('Trigoniæ,' pp. 10 and 48) upon the *Trigonia pectinata* of Lamarck, at that time the only known species of the section, so named from the external resemblance which their ornamentation bears to the *Pectines and Limæ;* the species, both living and Tertiary, are exclusively Australian. They present in their suborbicular Cardium-like forms, in their crenulated costæ radiating from the umbones, in their areas destitute of bounding carinæ or of divisional sulcations, in the absence of any clear separation between the dorsal and the anal or siphonal portions of the surface, a remarkable contrast to the *Trigoniæ* of the other continents; differences which are rendered the more remarkable when we examine the hinge features, which present little or no modification of the older Mesozoic forms of the genus; even the changes observable in the interiors of certain of the Cretaceous *Scabræ* and *Quadratæ* have also disappeared, and in the *Pectinidæ* we find reproduced unchanged the more ancient hinge features of the Mesozoic *Glabræ* in all their original prominence.

The European and American Tertiary formations, although occupying such extensive tracts of country and presenting every gradation of molluscan life, from extinct to living forms, are altogether destitute of the genus: it is only in the Tertiary Australian deposits of Victoria and of South Australia, associated with other existent generic forms, that we again discover *Trigoniæ*, represented solely by the group of the *Pectinidæ*, and more or less nearly allied to the few forms of the genus which inhabit the seas and tidal waters of the same region. This great hiatus in the chain of *Trigonia* life may possibly be eventually filled up by discoveries in some unknown series of the Tertiary formations. Widely, indeed, as the *Pectinidæ* are separated from the usual Mesozoic sectional forms, we discover some resemblance to a portion of the Cretaceous *Scabræ* both in their surface ornaments, and in the not less important absence of carinæ upon the superior and siphonal portions of the shell. There may also be observed in an Australian Tertiary species (*T. Howitii*, McCoy) a tendency to effacement of the ornaments over the middle portion of the valves, various examples of which occur in the Mesozoic *Undulatæ* and *Glabræ*. Perhaps some modification of this statement may be deduced from an examination of some known Cretaceous *Trigoniæ*. In *T. disparilis*, d'Orb. ('Ter. Crét.,' pl. 229), one of the *Scabræ* of the Terrain Sénonien, or highest chloritic marls of Tours, some approximation may be seen in the numerous crenulated costæ which radiate from the umbones over the middle portion of the valves; also in the minute *T. pulchella*, Reuss (Böhm., tab. 41), from a similar position in Bohemia; if, indeed, the latter species be not the very young condition of the former, which I am inclined to believe.

The American *T. Humboldtii*, von Buch, which has likewise costellæ radiating from the umbones over the upper, the anal, and the median portions of the shell, may also be regarded as a transitive or connecting species; these, however, are rare and exceptional forms in the great section of the *Scabræ*.

Within the last few years the Tertiary deposits of Australia have yielded several forms of *Trigonia;* these all belong to the section of the *Pectinidæ*, more or less allied to living forms. One small one, more especially allied to the species of Sydney Harbour, is named by Jenkins *T. Lamarckii* ('Geol. Mag.,' vol. iii, 1866, pl. 10, figs 3, 7), a name previously given by Matheron to a Cretaceous species (see p. 138). This Tertiary species is named by McCoy *T. acuticosta* ('Geol. Mag,' 1866, p. 481), from the beds of Mordialloc in Hobson's Bay. Other Tertiary species are *T. semiundulata*, McCoy, from Bird Rock Bluff, and *T. Howitii*, McCoy, from near the entrance to the Gippsland lakes. The latter in size nearly equals some of the larger Mesozoic forms, the length is twenty-six lines, the height twenty lines; it is remarkable for the great length of the hinge-border compared with the short perpendicular siphonal border; the middle portion of the shell has a tendency to the effacement of surface ornaments ('Ann. and Mag. Nat. Hist.,' ser. 4, vol. xv, pl. 18).

The distinctive differences of *T. acuticosta* as compared with the species of Sydney consist in the far more numerous costæ, their angulated forms, the lesser convexity of the valves, their more inequilateral figure, the greater breadth of the posteal slope, and greater length of the siphonal border: differences of small importance when viewed separately, but in the aggregate appearing to justify the separation claimed by McCoy for the Tertiary forms. They are, however, for the most part such as have been regarded as *varieties* among the Mesozoic *Trigoniæ* figured in this Monograph; and, should it eventually be decided to separate this small Tertiary species from the neighbouring living forms, it would undoubtedly be necessary to erect into species certain Mesozoic forms here tabulated as *varieties.*

T. semiundulata, McCoy, considered to approximate to the Jurassic *Trigoniæ costatæ* in its apparent concentric ribbing, is, nevertheless, one of the *Pectinidæ*, having the anteal and mesial costæ only slightly defined, crossed by undulating concentric ridges or lines of growth; in no other feature does it approach to Mesozoic forms.

The Tertiary Australian *Trigoniæ* deposited in the Melbourne National Museum have been assigned to the Miocene and Pliocene stages from a comparison of the percentage of living forms with which they are associated; but the question whether such a rule is applicable to Australian geology, and whether it affords a criterion whereby it may be measured with European Tertiary deposits, has yet to be determined.

The foregoing three Tertiary forms are so distinct from each other that there can scarcely remain a doubt of the propriety of regarding them as separate species; the small *T. acuticosta*, in its approach to the living Australian forms, will require further investigation, which will include the question of the separation of the living *Pectinidæ* into species and varieties, concerning which naturalists are much divided in opinion. Our present very insufficient knowledge upon this subject may be greatly augmented by the results of future dredging operations. A more precise estimate will be thus obtained of the hydrographical limits and habitats of forms, at present tabulated as species,

which are distributed in the shallow Coralline seas girding the eastern coasts of Australia, throughout more than thirty degrees of south latitude, from Cape York to Tasmania. Known, in one instance only, as a species of the sea, in other instances as denizens of land-locked waters, or of brackish waters in tidal rivers, these *Trigoniæ* do not appear to form varieties at any one locality. The differences between these species or varieties, chiefly founded upon their exterior forms and ornaments, will have to be considered and determined in connection with their aspects over the entire marine area occupied by each form. Eventually it may in this manner be possible to ground our knowledge of this section upon the living, in comparison with the Australian Tertiary, forms of the genus, and thus to legislate, with greater authority, upon the questions of species and varieties of the *Pectinidæ*.

In making comparisons of the species or varieties of the living *Pectinidæ*, we may select two Australian forms nearly allied, which have, of late years, become well known from their abundance; one of these is the *Trigonia* of that land-locked, fine expanse of water constituting Sydney Harbour, and the mud of its tributary, the Paramatta river, it is the *T. Lamarckii* of Jenkins and the *T. Jukesii* of Adams. It has been regarded by some naturalists as a variety only of a larger and nearly allied Tasmanian form, to which Lamarck's name, *Pectinata*, is now exclusively applied. The latter is abundant, buried in the black mud of the Launceston river, or in the tidal portion of it, the brackish water of which extends up the course of the channel for many miles. Separated from the habitat of the other shell by eight degrees of latitude, the difference of form, although only inconsiderable, is very persistent at each locality, and is instantly detected in the adult stage of growth. *T. pectinata* has the lesser convexity; the umbones are smaller and more oblique; the length of the siphonal border is greater; the costæ over the valve generally are less numerous; they are closely arranged anteally, but become widely separated over the middle of the valve, the spaces between them increasing towards the posteal slope; the costellæ upon the slope are small and inconspicuous, the costæ near to the border and throughout the circumference of the valve degenerate in their crenulations into closely placed imbricated lamellæ of growth, which are obscured by the greater development of the epidermal tegument; a similar feature is seen in various Mesozoic species, and notably in the Neocomian *Trigonia nodosa*.

The Sydney species has a similar kind of ornamentation; but, having larger and less oblique umbones, it is more globose; the hinge-area, corresponding with the escutcheon in the Mesozoic forms, is larger, and slightly excavated, and its ornamentation is more prominent than in *T. pectinata;* the costæ over the shell generally have smaller interstitial spaces, their crenulations become more square or flat-topped over the middle of the valves and near to the lower border. The siphonal border is always shorter and more perpendicular, forming a more considerable angle with the hinge-border; this feature from its prominence would alone be sufficient to separate the two forms. The young shell is usually more orbicular, having the siphonal portion less developed, it is

therefore sometimes not sufficiently illustrative of the fully developed growth of the species.[1]

The Sydney *T. Jukesii* is, however, nearly allied to another form which has been obtained rarely in the Coralline sea at Cape York, the most northernly point of Australia, separated by twenty-two degrees of latitude, and figured by Gray under the name of *Trigonia uniophora* ('Voyage of the Fly,' 1847, Appendix, pl. 2, fig. 5). The only essential difference between the latter and the species of Sydney appears to consist in the greater breadth of the posteal slope, and the greater length of the siphonal border in Gray's species—features which, unaccompanied by other distinctions, can only be regarded as constituting a varietal character.

To the foregoing living Australian forms of the *Pectinidæ* must also be added a single unnamed *Trigonia* upon the tablets of the British Museum, remarkable for the bizarre and anomalous character of the external ornaments, and especially for the characters of the costæ.

With our experience of the last few years it is easy to foresee that the missing connecting links between the Mesozoic and living *Trigoniæ* may be expected to be found in the Tertiary formations of Australia.

[1] Specimens with individual peculiarities occur; one of the Sydney Harbour *T. Jukesii*, Adams, in my possession, of adult growth, has in each valve an arrest of growth near to the pedal border; the left valve has three additional narrow interstitial costæ, the right valve having one such. An inordinate secretion of shell substance internally causes the valves to gape at the hinge-border, exposing the hinge processes with their transverse sulcations. A single, small, interstitial costa not unfrequently occurs in this species.

GEOLOGICAL DISTRIBUTION OF SPECIES AND VARIETIES OF BRITISH TRIGONIÆ, WITH REFERENCES TO THE FIGURES AND DESCRIPTIONS IN THE PRESENT MONOGRAPH.

TRIASSIC SYSTEM.

Rhætic Formation: allied genus, Myophoria.

		PAGE
	Myophoria postera, *Quenst.* Pl. xli, figs. 6, 6 *a*, 7, 7 *a*, 8, 8 *a*, 9, 9 *a*	212

JURASSIC SYSTEM.

Lower Lias.

Costatæ	? Trigonia modesta, *Tate.* Pl. xli, figs. 13, 13 *a*	212

Middle Lias.

Glabræ	Trigonia Lingonensis, *Dum.* Pl. xxii, figs. 1, 1 *a*, 2, 3, 4	98

Upper Lias.

Scaphoideæ	T. pulchella, *Ag.* Pl. xxxviii, figs. 10, 11, 12, 12 *a*	185
Undulatæ	T. literata, *Young & Bird.* Pl. xiv, figs. 1, 1 *a*, 2, 3, 4	64

MIDFORD OR SUPRA-LIASSIC SANDS.

Undulatæ	T. Leckenbyi, *Lyc.* Pl. xvi, figs. 1, 2	71
Clavellatæ	T. formosa, *Lyc.* Pl. v, figs. 4, 5, 6	35
	T. Ramsayi, *Wright.* Pl. vi, fig. 6	49
Costatæ	T. denticulata, *Ag.* Pl. xxix, figs. 1, 2, 3, 4	152

Inferior Oolite.

Scaphoideæ	T. Bathonica, *Lyc.* Pl. i, fig. 3	17
	T. duplicata, *Sow.* Pl. i, figs. 8, 9, 10	14
	T. gemmata, *Lyc.* Pl. i, fig. 7	15
	— (*var.* bifera), *Lyc.* Footnote	239
	T. recticosta, *Lyc.* Pl. i, figs. 4, 5, 6	16, 198

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Clavellatæ	T. Brodiei, *Lyc.* Pl. xxxv, figs. 8, 9	195
	T. formosa, *Lyc.* Pl. v, figs. 4, 5, 6; pl. xi, fig. 2; pl. xxxvii, fig. 10	35, 202
	T. — (*var.* lata). Pl. xxix, figs. 11, 12; pl. xxxv, fig. 7	35, 202
	T. parcinoda, *Lyc.* Pl. xxxvi, fig. 8	46
	T. Phillipsi, *Mor. & Lyc.* Pl. vi, figs. 3, 4	38
	T. signata, *Ag.* (Zieten's var.). Pl. ii, figs. 1, 2, 3	29, 204, 207
	T. spinulosa, *Young & Bird.* Pl. iii, figs. 4, 5 *a*, 5 *b*, 6	44
	T. striata, *Mil.* Pl. v, figs. 6', 7, 8	36
	T. tuberculosa, *Lyc.* Pl. v, figs. 9, 10	33
	T. Witchelli, *Lyc.* Pl. xxxviii, figs. 8, 9 (Fuller's Earth)	197
Undulatæ	T. angulata, *Sow.* Pl. xiv, figs. 5, 6; pl. xxxvii, figs. 7, 8, 9	54, 206
	T. compta, *Lyc.* Pl. xv, figs. 5, 6, 7; pl. xxxviii, fig. 4	70
	T. conjungens, *Phil.* Pl. x, figs. 5, 7, 8; pl. xiii, fig. 6	62
	T. costatula, *Lyc.* Pl. xv, figs. 8, 9, 10; pl. xii, fig. 6, 6 *a*	81
	T. producta, *Lyc.* Pl. xiii, figs. 1, 2, 3, 4; pl. xxxvii, figs. 1, 2	60, 208
	T. Sharpiana, *Lyc.* Pl. xv, fig. 11; pl. xvi, figs. 3, 4, 5, 6	79
	T. subglobosa, *Lyc.* Pl. xii, figs. 8, 9, 10	68
	T. v.-costata, *Lyc.* Pl. xiii, fig. 5; pl. xv, figs. 1, 2, 3, 4	66
Glabræ	T. Beesleyana, *Lyc.* Pl. xvii, figs. 2, 3, 4	91
Costatæ	T. bella, *Lyc.* Pl. xxxii, figs. 6, 7, 8, 8 *a*	126
	T. costata, *Sow.* Pl. xxix, figs. 5, 6, 7, 8	147
	T. — (*var.* lata). Pl. xxix, figs. 9, 10	149
	T. Culleni, *Lyc.* Pl. xxxi, figs. 9, 9 *a*	173
	T. denticulata, *Ag.* Pl. xxix, figs. 1, 2, 3, 4	152
	T. hemisphærica, *Lyc.* Pl. xxxi, figs. 4, 5, 6, 7, 8	174
	T. — (*var.* gregaria). Pl. xxxiii, figs. 4, 5, 6	176
	T. pullus, *Sow.* (small var.). Pl. xxxiv, figs. 7, 7 *a*, 8, 9	164
	T. sculpta, *Lyc.* Pl. xxxiv, figs. 1, 2, 2 *a*	157
	T. — (*var.* Cheltensis). Pl. xxxiv, fig. 3	159
	T. tenuicosta, *Lyc.* Pl. xxxiii, figs. 7, 8, 9, 9 *a*	160

GREAT OOLITE, STONESFIELD SLATE, FOREST-MARBLE, AND CORNBRASH.

Clavellatæ	T. Griesbachi, *Lyc.* Pl. iii, figs. 10, 10 *a*, *b*; pl. xxxvi, figs. 11, 11 *a*	34
	T. imbricata, *Sow.* Pl. vi, fig. 5; pl. xxxvi, figs. 9, 10. Fuller's Earth, pl. xli, figs. 10, 11, 12	33, 209
	T. impressa, *Sow.* Pl. vii, figs. 4, 5	46
	T. Moretoni, *Mor. & Lyc.* Pl. ii, figs. 4, 5, 7, 8; pl. iv, fig. 6	47
	T. Scarburgensis, *Lyc.* Pl. iv, figs. 1, 2, 3, 4	31, 200
Undulatæ	T. arata, *Lyc.* (*var.* of T. undulata, *From.*). Pl. xvi, figs. 9, 10, 11; pl. xvii, figs. 5, 6	77, 200
	T. Clytia, *d'Orb.* Pl. xi, figs. 4, 5; pl. xvii, fig. 7	76
	T. detrita, *Terq.* Pl. x, figs. 3, 3 *a*, 4	75
	T. flecta, *Lyc.* Pl. xiv, figs. 7, 8, 9, 10	55
	T. Painei, *Lyc.* Pl. xii, figs. 2, 3, 4, 5	59
	T. tripartita, *Forbes.* Pl. xii, fig. 7	74

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Costatæ	T. Cassiope, *d'Orb.* Pl. xxxii, figs. 1, 2, 4, 5	170
	T. costata (Cornbr.). Pl. xxix, figs. 5, 6, 7, 8	147
	T. elongata (*var.* angustata). Pl. xxx, figs. 1, 1 *a*, 2	154
	T. — (*var.* lata). Pl. xxx, figs. 4, 5	154
	T. sculpta, *Lyc.* (*var.* Rolandi). Pl. xxxiv, fig. 4	157
	T. pullus, *Sow.* Pl. xxxiv, figs. 7, 7 *a*, 8, 9	164

KELLOWAY ROCK, OXFORD CLAY, CORALLINE OOLITE, INCLUDING CALC. GRIT AND CORAL RAG.

Scaphoideæ	T. Snaintonensis, *Lyc.* Pl. xli, figs. 1, 1 *a*, 2, 3	198
Clavellatæ	T. Blakei, *Lyc.* Pl. xli, fig. 4	205
	T. clavellata, *Sow.* Pl. i, figs. 1, 1 *a*, 2; pl. iv, fig. 8	18, 209
	T. complanata, *Lyc.* Pl. vii, fig. 3	49
	T. corallina, *d'Orb.* Pl. viii, fig. 5; pl. iii, figs. 7, 8, 9, 11	45
	T. Hudlestoni, *Lyc.* Pl. xxxiv, figs. 5, 6; pl. xxxix, figs. 1 *a*, 2	194
	T. irregularis, *Seeb.* Pl. v, figs. 1 *a*, 1 *b*, 2; pl. vii, fig. 6; pl. xxxix, fig. 3	39
	T. perlata, *Ag.* Pl. iii, figs. 1, 2, 3; pl. xi, fig. 3	22
	T. Rupellensis, *d'Orb.* Pl. viii, fig. 4; pl. xxxvi, figs. 1, 2, 3, 4	28, 199
	T. triquetra, *Seeb.* Pl. vi, figs. 1, 1 *a*, 2; pl. xxxvi, fig. 7	26
	T. Williamsoni, *Lyc.* Pl. xvi, fig. 8; pl. xxxviii, fig. 7	53
Undulatæ	T. geographica, *Ag.* Pl. x, fig. 6; pl. xxxii, fig. 9	69
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Note.—Subsequently to the completion of this Monograph Mr. Witchell kindly forwarded to me a variety of *T. gemmata*, Pl. I, fig. 7, p. 15, which I propose to designate by the varietal name *bifera*. It has seven rows of concentric costæ, which occupy more than half the height of the valve. The oblique or perpendicular costæ, nine in number, have three only which originate at the marginal carina; all the others proceed from the last-formed concentric costa to the pallial border; the general figure is somewhat shorter than the typical form. Both varieties have occurred very rarely in a freestone bed of the Upper Trigonia Grit of the Inferior Oolite in the vicinity of Stroud.

CORRIGENDA.

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11 (Introduction). *For* the general sketch of the distribution of British Trigoniæ commencing at this page *substitute* the revised stratigraphical table of their distribution at the end of the Monograph, p. 235.

23, line 4. *Erase T. Bronnii*, Ag., pl. iv, fig. 8, and *substitute T. clavellata*, Ag., young specimen. *See* also p. 209 for description and figures of *T. Bronnii*, Ag.

42. Title to *T. incurva*, Ben., *alter* fig. 2 to *T. Alina*, Cont., var. *Alter* also explanation, fig. 2, facing pl. ix; *make it T. Alina*, Cont. It is also corrected upon the stratigraphical table, p. 237. Refer these to *T. incurva* and to *T. Alina*.

43. *Erase* line 26, commencing "No. 2 has suffered," to the word "pointed" at end of the sentence.

52. *For T. concentrica*, Ag., *see* p. 206.

59, line 4. *Read* few examples of *Trigonia paucicosta* have occurred at that locality.

62, line 7. *For* Northamptonshire *read* Oxfordshire at Hook Norton; see Pl. XXXVII, figs. 1, 2.

69. *T. geographica*, Ag.; see also Pl. XXXII, fig. 9.

74. *Erase* the concluding sentence of the description of *T. Carrei*, which refers to an unsatisfactory and doubtful specimen not figured.

77. *T. undulata*, From., var. *arata*, Pls. XVI and XVII; see also p. 201 for figures of the typical form of *T. undulata*.

84. *T. gibbosa*, Sow. *Erase* Pl. XVIII, fig. 3; also Pl. XIX, figs. 1, 1 *a*, 1 *b*. The references facing the plates are correct.

88. *T. Damoniana*, de Lor. *Erase* Pl. XX, figs. 1, 2, 2 *a*, 2 *b*, *substitute* Pl. XXI, figs. 2, 3, 4, 5, 2 *a*, 2 *b*. The references facing the plates are correct.

91. *T. Beesleyana*, Lyc. Additional well-preserved specimens exhibit a narrow, lengthened, depressed space upon the superior border, representing the escutcheon; the posteal slope, therefore, represents the area with its delicate transverse costellæ. There are no carinal elevations.

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94. *T. excentrica*, Park. *Alter* this name to *T. affinis*, Mill. and Sow.; see p. 187, Pl. XXI, fig. 7, and Pl. XXII, figs. 5, 5 *a*; also Pl. XL, fig. 2.

96, line 23. *Erase* the sentence commencing "The Chloritic Marls."

115, *T. Agassizii*, line 23. *Erase* this name and *substitute T. Upwarensis*, p. 143.

126, line 7 from the bottom. *For T. divaricata* read *T. disparilis*.

138, line 12. *For* Petref. Sulc. *read* Petref. Suecc.

140. Pl. XXIII, fig. 7. *Alter* to *T. Vicaryana*, Lyc.

159, line 2 from the top. *For* Shamford *read* Stamford.

174. *Trigonia hemisphærica*, var. *gregaria*, Pl. XXXIII, figs. 4, 5, 6. The examples of the small variety here represented have been incautiously selected for their good condition of preservation. The ribbing is unusually large, and does not exemplify the more common, smaller, and less clearly defined examples with minute or variable ribbing.

211, Addenda. *Erase* line 13, commencing "at the base of the Upper Greensands," and *substitute* "in one of the lower beds of Greensand at that locality." The pebble bed here alluded to is at the base of the fourth or highest stage of the Trigonia-bearing beds. For its species, &c., see the stratigraphical table.

EXPLANATION OF PLATES.

Pl. IV, fig. 8. *Erase* the name *T. Bronnii* and *substitute T. clavellata*, Sow., young specimen, see pp. 23 and 209.

Pl. IX, fig. 1. *Erase* Wilts and *substitute* St. Adhelm's Head, Dorset.

Pl. IX, fig. 2. *Alter T. incurva* to *T. Alina*, Cont. *Alter* page 42 to page 193.

Pl. IX, fig. 3. *Add T. incurva*.

Pl. IX, fig. 4. *Alter* the locality to St. Adhelm's Head, Dorset.

Pl. XIX, figs. 4 *a*, 4 *b*. The encircling costæ upon the umbones of *T. Manseli* are not sufficiently numerous and minute.

Pl. XXI, figs. 2 *a*, 2 *b*. The encircling costæ upon the umbones are not sufficiently linear and minute; this feature alone is sufficient to separate the form from *T. gibbosa*.

Pl. XXI, fig. 7. *Add* the words *T. affinis*. See page 187.

Pl. XXIII, fig. 7. *Alter T. Archiaciana*, D'Orb., to *T. Vicaryana*, Lyc. *Alter* page 140 to page 203.

Pl. XXXIV, fig. 1. *T. sculpta*. The figure of the right valve appears to represent an ante-carinal groove adjacent to the marginal carina. This is owing to the person who cleared the fossil from its matrix having heedlessly removed the posteal extremities of the costa, which should extend to the carina, as in other examples of the *Costatæ*.

The author desires to record his obligations to the artists engaged upon the plates of this Monograph for the general care and fidelity to nature which they evince—the first nine plates by the late Mr. Lackerbauer, the succeeding plates by M. Karmansky, the last plate by a son of the late Mr. Lackerbauer. The wood engravings up to p. 122 are by Mr. Dewilde; the subsequent ones, by Mr. G. Shayler, are carefully drawn exemplifications of foreign Trigoniæ.

ALPHABETICAL INDEX OF SPECIES AND VARIETIES OF TRIGONIA REFERRED TO IN THIS MONOGRAPH.

Species known under other names and synonyms are printed in *italics*. The letters F. S. following species indicate that the form has not been found in Britain.

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PLATE XLI.

FIG.

1, 1 *a*, 2, 3. *Trigonia Snaintonensis*, Lyc. Passage Beds of the Lower Calcareous Grit, Snainton, near Scarborough. (Page 198.) Coll. Hudleston.

4. ,, *Blakei*, Lyc. Passage Beds of the Lower Calcareous Grit, Snainton, near Scarborough. (Page 205.) Coll. Hudleston.

5. ,, *debilis*, Lyc. Chloritic Marls, Dunscombe Cliffs. See also Plate XL, fig. 8. (Page 189.) My collection.

6, 8. ,, *Myophoria postera*, Quenst. The left valve, natural size. Rhœtic Limestone, near Ilminster. (Page 215.) Coll. Moore.

6 *a*, 8 *a*. ,, ,, ,, The same valve, enlarged.

7, 9, ,, ,, ,, The right valve, natural size. Coll. Moore.

7 *a*, 9 *a*. ,, ,, ,, The right valve, enlarged.

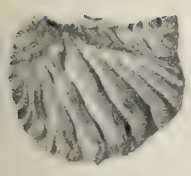
10, 11, 12. ,, *imbricata*, Sow. Fullers Earth, Stroud. See also Plate VI, figs. 5 *a*, *b*; and Plate XXXVI, figs. 9, 10. (Page 33.) Coll. Witchell.

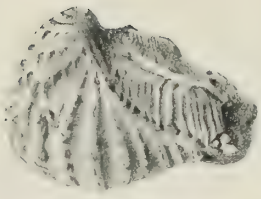
13, 13 *a*. ,, ? *modesta*, Tate. Natural size and enlarged. Lower Lias, Warter's Bay, near Whitby. (Page 212.) Coll. Rev. J. F. Blake.

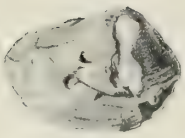
14. ,, *Dunscombensis*, Lyc. Chloritic Marls, Dunscombe Cliffs, South Devon. See also Plate XL, fig. 5. (Page 188.) My collection.

15, 16. ,, *Meyeri*, Lyc. Chloritic Marls, Dunscombe Cliffs. See also Plate XXIII, fig. 6. (Page 125.) My collection.

17. ,, *costigera*, Lyc. Chloritic Marls, Dunscombe Cliffs. (Page 205.) My collection.







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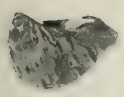

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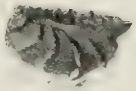

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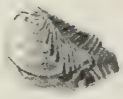

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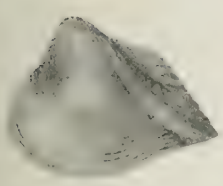

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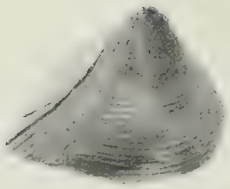

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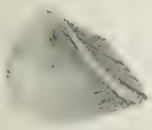

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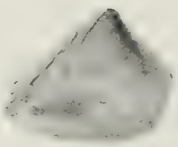

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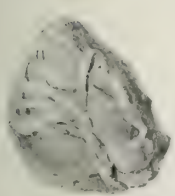

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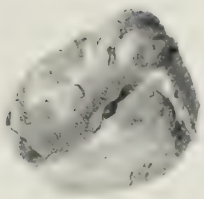

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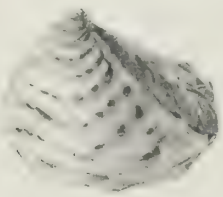

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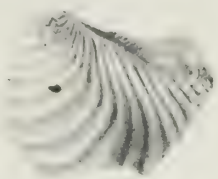

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MONOGRAPH

ON THE

LIAS AMMONITES

OF

THE BRITISH ISLANDS.

BY

THOMAS WRIGHT, M.D., F.R.S. EDIN., F.G.S.,

VICE-PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY; CORRESPONDING MEMBER OF THE ROYAL SOCIETY OF SCIENCES OF LIÈGE; THE SOCIETY OF NATURAL SCIENCES OF NEUCHÂTEL; VICE-PRESIDENT OF THE COTTESWOLD NATURALISTS' FIELD CLUB; CONSULTING SURGEON TO THE CHELTENHAM HOSPITAL; AND MEDICAL OFFICER OF HEALTH TO THE URBAN SANITARY DISTRICTS OF CHELTENHAM, CHARLTON KINGS, AND LECKHAMPTON.

PART SECOND—THE LIAS FORMATION.

PAGES 49—164; PLATES IX—XVIII.

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5. The Zone of Arietites obtusus.

Synonyms.—"Marston-Marble," Sowerby, 'Min. Conch.,' Suppl. Index, vol. i, 1812. "Indurated marl and limestone-beds," De la Beche, "Section," &c., 'Geol. Trans.,' 2nd ser., vol. ii, pl. iii, 1823. "Turnerthone," Quenstedt, 'Flözgeb. Württembergs,' p. 157, 1843. "Ammonite-bed (Lower Lias)," Murchison, 'Geol. of Cheltenham,' 2nd edit., p. 42, 1845. "Sable d'Aubange" (partie infer.), Dewalque et Chapuis, 'Luxembourg,' p. 12, 1853. "Die Schichten des *Ammonites obtusus*," Oppel, 'Jura-formation,' p. 50, 1856. "Grès de Virton" (partie infer.), Dewalque, 'Lias de Luxembourg,' p. 48, 1857. "Zone of *Ammonites obtusus*," Wright, 'Quart. Journ. Geol. Soc.,' xvi, p. 404, 1860.

Gloucestershire and Warwickshire.—The beds constituting this zone are well developed in the Vale of Gloucester, and were exposed in cutting the Bristol and Birmingham Railway, near Bredon, from whence the best collection of the fossils from this zone in the Midland Counties was obtained. The rocks consist of dark-grey and bluish shales and clays, with irregular and inconstant beds of dark-grey argillaceous limestone, the shales being in part nodular and laminated, the clays thick and tenacious, and the nodular portions of the shales very fossiliferous. Several of the *Arietites obtusus* and *Arietites stellaris* had their shells well preserved, and the outer layers of the same were adorned with numerous parallel, longitudinal, spiral lines, consisting of punctuated elevations, which extend along the sides, dip into the depressions, and rise on the central elevation of the siphonal area. This ornamentation is limited to the external lamina of the shell, as no impression of it is left on either the nacreous layer or the mould. I have rarely found these punctuated lines so well preserved as in the specimens I have figured of *Arietites obtusus*, from Bredon and Lyme, and in the remarkable specimen of *Arietites stellaris*, from Lyme, preserved in the original Sowerbyan Collection now in the British Museum. So seldom is this specific shell-structure observed that many palæontologists deny its existence in these species, but after the figures I have given all doubt upon the subject must be removed. In Warwickshire this zone forms part of the Cardinia-bed and contains some very fine specimens of *Arietites obtusus*, *Ar. multicostatus*, *Ar. Brookii*, and *Ar. Sauzeanus*, d'Orb.

Dorsetshire.—At Lyme Regis the *Obtusus*-zone attains a considerable thickness, and is well shown in the coast-section. The strata rise on the shore about half a mile west of Charmouth, and consist of thick beds of dark marls, which rest upon the table-bed formed by Broad Ledge. The lower part of the marls contains numerous compressed *Aegoceras Birchii*, Sow., and layers of nodules forming cement-stones. Above these succeed shales and clays, thin bands of limestone, and thick beds of shale and marls with mudstones. Above these again are inconstant bands of limestone containing septaria, in which gigantic examples of *Arietites obtusus*, *Arietites stellaris*, and *Arietites Brookii* are found. The following section shows the relative position of these beds.

Section from Broad Ledge to Cornstone Ledge, near Charmouth.

No.	Lithology.	Thickness.	Organic Remains.
		ft. in.	
1	Dark-grey limestone. "Cornstone Ledge."		Fishes in fine preservation as *Pachycormus, Æchmodus, Dapedius, Acrodus, Hybodus,* &c.
2	Dark-bluish marls	20 0	
3	Dark-greyish limestone	0 10	*Ichthyosaurus platyodon,* Conyb., and *I. intermedius,* Conyb. *Aegoceras Birchii,* Sow.
4	Dark clays.		
5	Dark limestone, with nodules and septaria.....		*Nautilus striatus,* Sow., *Arietites Brookii,* Sow., and *Arietites stellaris,* Sow. (very large).
6	Dark shale.		*Dapedius punctatus, Dapedius Colei,* Ag.
7	Dark limestone. "Upper Cement-bed"	3 0	*Dapedius granulatus. Æchmodus pustulatus,* Ag.
8	Dark shales, containing mudstone nodules at the base	9 0	*Scelidosaurus Harrisonii,* Owen. *Inoceramus pinnæformis. Lepidotus fimbriatus,* Agass.
9	Thin band of limestone. The "Pentacrinite bed".....		*Extracrinus Briareus,* Mill.
10	Dark shales.	4 0	*Arietites stellaris. Ar. semicostatus.*
11	Dark limestone. "Fire-ledge."	2 0	
12	Dark shale.	4 0	*Chondrosteus acipenseroides,* Agass.
13	Dark limestone.	2 0	*Chondrosteus, Lepidotus, Conodus ferox,* Ag.
14	Dark shale.		
15	Dark limestone "Split-ledge."	2 0	*Aegoceras planicosta,* Sow., and *Arietites Smithii, Ar. obtusus,* Sow., *Lepidotus rugosus,* Ag.
16	Dark shales	5 0	Saurian skeletons. Fishes.
17	Greyish limestone crystallised, forming the "Tortoise-ammonites".....	2 6	*Arietites obtusus,* Sow., and *Aegoceras Birchii,* Sow.
18	Dark marls, with nodular masses. The lower Cement-beds &c. &c.....	30 0	The nodules contain Saurian remains. *Pentacrinus,* sp., *Ichthyosaurus platyodon.*
19	Dark indurated shale and limestone. "Broad Ledge,"	4 0	This bed overlies the Lima-series east of Lyme-Regis.
20	The Nut rocks	3 0	*Aegoceras Birchii,* Sow.
	Zone of Arietites Turneri.		
	Thick Limestone : Broad Ledge.		Saurian Skeleton.

The *Obtusus*-zone attains a thickness of from 80 to 100 feet; its actual measurement is a matter of difficulty, the marls having covered up the bands of limestone.

In the lower marls are many compressed specimens of *Aegoceras Birchii*, which fall to pieces when removed from the matrix. Higher up (No. 17) this Ammonite is found in fine preservation, with *Arietites obtusus*. Here the shells are replaced, and their chambers filled, with crystallised carbonate of lime. These beautiful specimens are the "Tortoise-ammonites" of local collectors. About 40 or 50 feet above the latter an irregular band of limestone (5) is seen projecting from the cliff, containing nodules with very large specimens of *Arietites obtusus,* Sow., *Arietites stellaris,* Sow., and *Arietites Brookii,* Sow. Most of the nodules have a septarian structure, the veins of spar intersecting and distorting the fossil contents of the bed.

Below the ammonitiferous nodules (5 of the section) other bands of clay and marl (6 to 14) succeed. In one of these (9) are thin, wide-spread layers of Crinoidal limestone, on the surface of which magnificent specimens of *Extracrinus Briareus,* Mill., are

found, with their plant-like arms laid out in all directions, and generally coated with ferric disulphide. The remarkable Liassic Dinosaurian *Scelidosaurus Harrisonii*, Ow., so fully figured and ably described by my friend Professor Owen, F.R.S., in the Palæontographical Society's volume for 1859, was discovered some years ago by Mr. Samuel Clarke, of Charmouth, in the dark shales of bed No. 8, above the mudstones.

Fossils of the Zone of Arietites obtusus *at Lyme Regis.*

Ichthyosarus platyodon, *Conby.*
Scelidosaurus Harrisonii, *Owen.*
Dapedius granulatus, *Agass.*
Pachycormus heterurus, *Agassiz.*
Æchmodus Leachi, *Egerton.*
Lepidotus rugosus, *Agassiz.*
Condostreus crassior, *Egerton.*
Arietites obtusus, *Sow.*
— Brookii, *Sow.*
Arietites stellaris, *Sow.*
— Sauzeanus, *d'Orb.*
Aegoceras planicosta, *Sow.*
— Birchii, *Sow.*
Nautilus striatus, *Sow.*
Belemnites acutus, *Mill.*
Pleurotomaria similis, *Sow.*
Inoceramus pinnæformis, *Dunk.*
Extracrinus Briareus, *Mill.*

Foreign Correlations.—The zone of *Arietites obtusus* is developed in Germany, although this Ammonite appears to be rare. Some of the specimens I saw in the collections had been mistaken for *Arietites Turneri* and were labelled as such. In North Germany argillaceous beds, with *Aegoceras planicosta*, Sow., and *Aeg. ziphus*, Hehl., representing this zone, are found resting on Arietenschichten in several localities, as near Harzburg, Liebenburg, Hildesheim, Jexheim, Goslar, the Markoldendorfer Mulde, near Steinberg, Falkenhagen, and the Empelder Ziegelei, near Hanover.

In South Germany the zone is developed in Swabia, at the foot of the Alp from Boll towards Randern. *Arietites obtusus*, Sow., is found likewise near Betzingen, Balingen, and Aselfingen.

Fossils from the planicosta-beds of North Germany = the obtusus-beds of England.

Arietites obtusus, *Sow.*
— Sauzeanus, *d'Orb.*
Aegoceras planicosta, *Sow.*
— ziphus, *Hehl.*
— tamariscinum, *Schlön.*
Belemnites acutus, *Mill.*
Hydrobia cerithiiformis, *Piette.*
Turritella undulata, *Benz.*
Turbo paludinæformis, *Schübl.*
Cryptænia expansa, *Sow.*
Dentalium Etalense, *Terq.*
Cylindrites fragilis, *Dunk.*
Pleuromya liasina, *Schübl.*
Goniomya heteropleura, *Agass.*
Pholadomya corrugata, *Dunk.*
Protocardia oxynoti, *Quenst.*
Lucina problematica, *Terq.*
Modiola scalprum, *Sow.*
Avicula inæquivalvis, *Sow.*
Gervillia olifex, *Quenst.*
Perna Pellati, *Dumort.*
Cucullæa Münsteri, *Ziet.*
Leda complanata, *Sow.*
Lima gigantea, *Sow.*
— pectinoides, *Sow.*
Pecten textorius, *Schloth.*
Plicatula spinosa, *Sow.*
Gryphæa cymbium, *Lamk.*
Waldheimia cor, *Lamk.*
Spiriferina rostrata, *Schloth.*
Rhynchonella variabilis, *Schloth.*
Lingula Voltzii, *Terq.*

In France this zone is so closely connected with other Lower Lias beds resting upon it, that it has not been accurately defined and separated from them. Its specific Ammonite forms have, however, been collected in different Departments. Thus, *Arietites obtusus, Arietites stellaris, Aegoceras Birchii, Aeg. planicosta,* have been collected near Avallon, Yonne; and at Semur, Côte d'Or; also at Couzon, near Lyons; and at Nancy, Meurthe. The same species were likewise collected, according to M. Dumortier,[1] from St. Fortunat, St. Cyr, Rhône; St. Christophe, Saône-et-Loire; St. Rambart, Ain; affording evidence of the existence of this zone of life through a considerable area of the Sinemurian Lias.

M. Marcou, in the Jura of Salins,[2] described under the name "Marnes de Balingen ou à Gryphæa cymbium" three stages resting upon the Tuberculatus-beds; these were—1st, beds with *Arietites obtusus;* 2nd, beds with *Amaltheus oxynotus;* and 3rd, beds with *Arietites raricostatus;* and these resembled the formation near Balingen, so that in the Jura the *Obtusus*-zone is developed, as it is likewise in other localities in Switzerland.

6. The Zone of Amaltheus oxynotus.

Synonyms.—"Oxynoten-Schichte," Fraas, 'Württemb. naturw. Jahreshefte,' p. 206, 1847. "Die Schichten des *Ammonites oxynotus*," Oppel, 'Die Juraformation,' p. 54, 1856. "Oxynotenlager," Quenstedt, 'Der Jura,' p. 293, 1858. "Oxynotus-bed," Wright, 'Quart, Journ. Geol. Soc.,' vol. xiv, p. 25, 1858. "Zone of *Ammonites oxynotus*," Wright, 'Quart. Journ. Geol. Soc.,' vol. xvi, p. 406, 1860. "La Zone de "*l'Ammonites oxynotus*," Dumortier, 'Études Paléont.,' t. ii, p. 238, 1867. "Zone of *Ammonites oxynotus*," Tate and Blake, 'Yorkshire Lias,' p. 7, 1876.

Gloucestershire.—This zone consists of beds of dark clays, which often contain much ferrous sulphide and ferric oxide, and the fossils found in these clays are either highly pyritic or charged with the peroxide of iron. This zone was exposed in cutting the Bristol-and-Birmingham, and Great-Western Railways; at Lansdown, near Cheltenham; and in excavating the new docks at Gloucester; I have collected its characteristic fossils at Swindon and at some localities in the Valley of the Severn.

Dorsetshire.—Amaltheus Lymensis, the representative species, in the south, of *Amaltheus oxynotus* in the Midland Counties—is found in a thin bed of dark, pyritic marl between Charmouth and Lyme Regis, near Black Venn. It is here collected with other species, which properly belong to a higher bed; the talus of the upper marl, from the decay of the bank, making it difficult to separate the beds.

Yorkshire.—The *Oxynotus*-zone is well seen in Robin Hood's Bay, and the following detailed section by MM. Tate and Blake,[3] including likewise the *Obtusus*-zone and

[1] 'Études Paléont. Dépôts Jurassiques du Bassin du Rhône,' tome ii, p. 103, 1867.

[2] 'Jura Salinois,' Mém. Soc. Géol. de France, 1846.

[3] 'Yorkshire Lias,' p. 73, 1876.

raricostatus-zone, is most valuable for showing the stratigraphical distribution of the Ammonites therein. The upper half of the section, Nos. 1—20, represents the *raricostatus;* Nos. 21—26 the *oxynotus;* and the lower portion, Nos. 27—45, the *obtusus*-zone.

Section of the Oxynotus-beds, *Robin Hood's Bay.*

No.	Lithology.	Thickness.	Organic Remains.
		ft. in.	
1	Indurated sandy band, with nodules of broken fossils	1 6	*Belemnites.*
2	Blue shale	8 6	
3	Hardened band	0 3	*Pecten priscus, Cardinia hybrida, Gryphæa obliquata, Belemnites.*
4	Blue shale	7 0	*Homomya ventricosa.*
5	Hardened band	0 3	
6	Blue shale	4 0	
7	Blue shale, with variable indurated bands, thick in places	7 0	
8	Hard band	0 4	
9	Soft clayey band in places	0 3	
10	Hard blue shales	2 6	
11	Rubbly variegated hard band	0 4	
12	Blue breakable shales	2 10	*Lima pectinoides.*
13	Rubbly variegated band	0 3	These three bands run close together, and make a feature in the cliff.
14	Blue shale	0 10	
15	Hard band	0 2	
16	Shale	1 0	*Nautilus striatus.*
17	Hard band	0 3	
18	Blue shales	3 7	*Pentacrinus tuberculatus.*
19	Line of fossiliferous nodules	0 3	*Ar. raricostatus, Amal. densinodus, Lima pectinoides, Pecten priscus, Monotis inæquivalvis.*
20	Blue shales	1 8	*Pecten calvus, Lima pectinoides, Rhynchonella calcicosta.*
21	Hard limestone band, with erect annelid (?) tubes	0 8	*Amal. Simpsoni, Nautilus striatus.*
	Parting of shale.		
22	Hard limestone band	2—4 8—6	*Gryphæa obliquata, Homomya ventricosa.*
23	Blue crumbly shale	1 3	*Aeg. gagateum, Lima pectinoides, Modiola lævis, Cardinia hybrida.*
24	Hard rubbly stone	0 4	
25	Blue crumbly shales, with bands of scattered irregular doggers	5 8	*Amal. oxynotus, Aeg. gagateum, Belemnites acutus, Pecten calvus, Protocardium oxynoti.*
26	Marly stone, with *Pentacrinus* band and cone-in-cone structure		*Pentacrinus tuberculatus, Actæonina fragilis, Hydrobia solidula, Leda Heberti, Lima pectinoides.*
27	Shales with many scattered sandstone doggers, and shell layer towards the base	5 10	*Aeg. planicosta, Lima pectinoides, Cardinia hybrida, Gryphæa obliquata.*
28	Hardened band	0 5	
29	Soft shale	1 7	
30	Whitened calcareous band	0 3	
		69 7	

No.	Lithology.	Thickness.	Palæontology.
		ft. in.	
	Brought over	69 7	
31	Variable blue-black shales, with scattered doggers; flat	14 0	*Pentacrinus tuberculatus.*
32	Thin whitened band	0 2	
33	Shales	1 4	*Aeg. sagittarium, Bel. acutus,*
34	Whitened band	8–10	*Ostrea arcuata, Bel. acutus.*
35	Shales	5 0	*Aeg. sagittarium, Pent. tuberculatus.*
36	Harder whitened band	0 9	
37	Shale	2 3	*Aeg. sagittarium, Bel. acutus, Ostrea arcuata.*
38	Thick whitened band	1 8	
39	Blue shale, unseen in the cliff with line of crustacean nodules		*Aeg. planicosta, Ar. obtusus, Ar. stellaris, Aeg. sagittarium, Hippopodium ponderosum.*
40	Hard brown limestone band, forming a scar	0 5	
41	Hard blue shale, with line of scattered doggers three feet down	8 0	*Pentacrinus tuberculatus, Bel. acutus, Pecten priscus, Ostrea arcuata.*
42	Hard calcareous rubbly stone, forming a *very* strong continuous scar	1 3	
43	Blue shale with oyster beds	2 4	*Pent. tuberculatus, Pecten priscus, Ostrea arcuata.*
44	Indurated limestone band	4 6	*Ostrea arcuata, Cardinia hybrida, Hippopodium ponderosum.*
45	Soft blue smooth shale, with round nodules	3 6	*Aeg. planicosta.*
46	Indurated calcareo-argillaceous rubbly band, speckled brownish	0 2	
	Total thickness	107 10	

The palæontology of the *Oxynotus*-zone is remarkable for the small number of species it contains, when compared with the richness of the *Bucklandi*- and *Angulatum*-zones which preceded and the fertility of the *Jamesoni*-zone which succeeded it.

Fossils of the Oxynotus-zone.

Cephalopoda.

Amaltheus oxynotus, *Quenst.*
— Lymensis, *Wright.*
— Oppeli, *Schlönbach.*
— denotatus, *Simpson.*
— impendens, *Young & Bird.*
— Simpsoni, *Bean.*
— Guibalianus, *d'Orbig.*
Aegoceras biferum, *Quenst.*
Aegoceras lacunatum, *Buck.*
— gagateum, *Young & Bird.*
— sagittarium, *Blake.*
Nautilus intermedius, *Sow.*
Belemnites acutus, *Mill.*
— calcar, *Phill.*
— penicillatus, *Sow.*

Gasteropoda.

Pleurotomaria similis, *Sow.*
Actæonina fragilis, *Dunk.*
Cerithium gratum, *Terq.*
Turritella Dunkeri, *Terq.*
— Zenkeni, *Dunk.*
Hydrobia solidula, *Dunk.*

LAMELLIBRANCHIATA.

Gryphæa obliquata, *Lamk.*
Ostrea Goldfussi, *Bronn.*
Pecten priscus, *Schloth.*
— æqualis, *Quenst.*
— calvus, *Goldf.*
Lima gigantea, *Sow.*
— pectinoides, *Sow.*
Monotis inæquivalvis, *Sow.*
Pinna folium, *Young & Bird.*
— Hartmanni, *Ziet.*
Leda Heberti, *Mart.*
— subovalis, *Goldf.*
— Galathea, *d'Orb.*
Cucullæa Münsteri, *Ziet.*
Modiola scalprum, *Sow.*
Protocardia oxynoti, *Quenst.*
Astarte obsoleta, *Dunk.*
Nucula navis, *Piette.*
Hippopodium ponderosum, *Sow.*
Cardinia hybrida, *Sow.*
Unicardium cardioide, *Phill.*
Homomya ventricosa, *Agass.*
Arcomya vetusta, *Phill.*
Gresslya Galathea, *Agass.*
Rhynchonella calcicosta, *Quenst.*
Rhynchonella oxynoti, *Quenst.*

ECHINODERMATA.

Cidaris spines.
Acrosalenia minuta, *Buck.*
Pentacrinus tuberculatus, *Mill.*
— basaltiformis, *Mill.*

7. The Zone of Arietites raricostatus.

Synonyms.—"Hippopodium-bed" (pars), Murchison's 'Geology of Cheltenham,' 2nd ed., by Buckman and Strickland, p. 44, 1845. "Raricostatenschicht," Fraas, 'Württemb. naturw. Jahreshefte,' pl. 3, 1847. "Die Schichten des *Ammonites raricostatus*," Oppel, 'Die Juraformation,' p. 56, 1856. "Raricostatenbank," Quenstedt, 'Der Jura,' p. 293, 1858. "Raricostatus-bed," Wright, 'Quart. Journ. Geol. Soc.,' vol. xiv, p. 25, 1858. "Zone of *Ammonites raricostatus*," Wright, 'Quart. Journ. Geol. Soc.,' vol. xvi, p. 407, 1860. "Die Schichten des *Ammonites ziphus*" (pars), Brauns, 'Die Untere Jura,' p. 90, 1871.

The beds forming this zone are exposed in several brick-fields in the Vale of Gloucester. They consist of dark-coloured clays, more or less impregnated with ferric oxide. In an excavation made at Marle Hill, near Cheltenham, for brick-earth, the following section was obtained. The beds are enumerated in descending order.

No.		ft.	in.
1.	*Gryphæa-bed;* a hard, ferruginous clay, which broke into fragments, and contained a great many specimens of *Gryphæa obliquata*, Sow. ..... 3 ft. to	4	0
2.	*Coral-band;* a thin seam of lightish-coloured unctuous clay, containing a great many small, sessile Corals, *Montlivaltia rugosa*, Wrt., most of which appeared to have been attached to the curved valves of the *Gryphæa*..... 1 in. to	0	1½
3.	*Hippopodium-bed;* a stiff dark-coloured clay, in some parts ferruginous; containing *Cardinia Listeri*, Sow., and *Hippopodium ponderosum*, Sow., in considerable numbers ..... from 8 ft. to	10	0
4.	*Ammonite-bed;* a dark, ferruginous clay, containing selenite, ferric oxide, and ferrous sulphide, and great numbers of a highly pyritic brood of *Aegoceras subplanicosta*, Opp., *Aegoceras densinodum*, *Arietites raricostatus*, *Arietites Nodotianus*, and the other species of the list	Not ascertained.	

At Cleeve, near Cheltenham, the same beds were formerly worked for brick-earth; and the finest specimens of *Cardinia Listeri*, Sow., *Hippopodium ponderosum*, Sow., *Arietites raricostatus*, Ziet., and *Pleurotomaria similis*, Sow., were obtained here. At Bredon these beds were laid open in the railway-cutting, and yielded a rich series of the characteristic fossils. In Warwickshire the railway-cutting at Honeybourne exposed the same zone; and here also the Coral-band contained a considerable number of *Montlivaltia rugosa*, Wrt., and the Ammonite-bed its leading species.

At Lyme Regis, in Dorsetshire, this zone is found near Black Venn, and some of the beds contain a large quantity of pyrites, so much so that during the winter months they are worked for that mineral, when their characteristic *Ammonites* are collected in considerable numbers; unfortunately most of the fossils are so much charged with pyrites that they are preserved with difficulty.

At Robin Hood's Bay, on the coast of Yorkshire, this zone is closely associated with the *Oxynotus*-beds and cannot be separated from them; it is seen resting on the underlying clays with *Amaltheus oxynotus*, and is overlain by thick clays containing *Aegoceras Jamesoni*, Sow. In all these localities there appears to be an absence of limestone-layers, the clay, more or less impregnated with iron in different stages of oxidation, constitutes the entire beds.

My friend Mr. E. C. H. Day, F.G.S., collected for me at the small bay of Ballintoy, in the north of Ireland, a number of fossils from this zone. The box he kindly sent me from that locality contained the following species:

Cephalopoda.

Arietites raricostatus, *Ziet.*
— Nodotianus, *d'Orb.* = Macdonnelli, *Portlock.*
Aegoceras subplanicosta, *Oppel.*
Aegoceras armatum densinodum, *Quenst.*
— muticum, *D'orb.*
Belemnites acutus, *Mill.*
— penicillatus, *Sow.*

Gasteropoda.

Pleurotomaria similis, *Sow.*
Turritella Dunkeri, *Terq.*

Lamellibranchiata.

Gryphæa obliquata, *Sow.*
Plicatula spinosa, *Sow.*
Leda oxynoti, *Quenst.*
Pecten Hehlii, *d'Orb.*
— æqualis, *Quenst.*
Hippopodium ponderosum, *Sow.*
Protocardia truncata, *Sow.*
Goniomya rhombifera, *Quenst.*
Homomya ventricosa, *Agass.*

Brachiopoda.

Waldheimia perforata, *Piette.*
Rhynchonella variabilis, *Schloth.*

Fossils of the Zone of Arietites raricostatus *from near Cheltenham.*

Cephalopoda.

Aegoceras armatum densinodum, *Quenst.*
— lacunatum, *Buck.*
— muticum, *d'Orb.*
— subplanicosta, *Oppel.*
Arietites Nodotianus, *d'Orb.*
— raricostatus, *Ziet.*
Belemnites acutus, *Mill.*
Nautilus striatus, *Sow.*

Gasteropoda.

Chemnitzia parva, *Wright.*
Pleurotomaria similis, *Sow.*
Pleurotomaria raricostæ, *Tate.*
Cryptænia expansa, *Sow.*

Lamellibranchiata.

Limea acuticosta, *Münst.*.
Cardinia hybrida, *Sow.*
Gryphæa obliquata, *Sow.*
Hippopodium ponderosum, *Sow.*
Ostrea raricostæ, *Wright.*
Pecten æqualis, *Quenst.*
Pleuromya oblonga, *Wright.*
Unicardium cardioide, *Phill.*

Brachiopoda.

Lingula Metensis, *Terq.*
Rhynchonella variabilis, *Schloth.*
Spiriferina Walcotii, *Sow.*
Waldheimia numismalis, *Schloth.*

Polyzoa.

Berenicea striata, *Haime.*
Stromatopora antiqua, *Haime.*

Echinodermata.

Acrosalenia minuta, *Buck.*
Pentacrinus scalaris, *Goldf.*

Anthozoa.

Montlivaltia mammiformis, *Dunc.*
— mucronata, *Dunc.*
Montlivaltia radiata, *Dunc.*
— rugosa, *Wright.*

Foreign correlations.—The *Oxynotus*-beds in Württemberg so closely resemble those near Cheltenham, both in their Petrology and Palæontology, that when examining the fossils from these rocks in the Stuttgart and Tübingen Museums I failed to see any difference between the German and the English specimens; so much alike were they that, without marking the fossils before comparing them, I should have mistaken the one for the other. This was especially the case with *Aegoceras biferum*, *Aeg. lacunatum*, and *Amaltheus oxynotus*. This zone is feebly developed in some of the Departments of France. M. Marcou has found its fossils in the Jura Department. Few of the Ammonites appear to have passed into M. d'Orbigny's hands, as neither of the three leading species enumerated above is figured in the 'Paléontologie Française,' unless it may turn out

on closer study that *Amaltheus Lynx*, d'Orb., and *Amal. Coynarti*, d'Orb., from the Middle Lias "*du Bois-de-Trousse, près de Saint Amand* (*Cher*), *où elle est passée à l'état de fer sulfuré ou de fer hydraté*," be French forms of *Amal. oxynotus*. I failed to find the type of *Amal. Lynx* and *Amal. Coynarti* in the d'Orbignyan Collection in the Jardin des Plantes.

From the Bassin du Rhône M. Dumortier has given a very full list of the fossils in his collection which he refers to this zone, and observes,[1] when studying the fossils of the zone de l'*Ammonites oxynotus*, the fact that strikes one most is the important place which the Ammonites occupy. The number and variety of the species, the abundance of certain types, and above all the invariable regularity of their stratigraphical position, well deserve attention. In relation to their form, the Ammonites of the superior zone cannot be attached by preference to any particular type, inasmuch as we recognise at the same time shells with numerous and narrow whorls extremely evolute and provided relatively with an enormous umbilicus, as well as species entirely convolute and without a trace of umbilicus; certain forms having large, round backs, whilst others are provided with sharp and prominent carinæ. The external ornamentation exhibits the same variety; sometimes the shell is simple and without ornament, whilst in others the surface is provided with the richest decoration.

The Gastropods, less rare than in the lower zone, are not, however, of much importance. Among the Lamellibranchiata the *Gryphæa obliqua* occcupies an exceptional position by the immense number of its individuals. The *Pleuromyæ* in this division of the Lias attain their maximum development; and the *Cardinia philea*, d'Orb., and *Hippopodium ponderosum*, Sow., in consideration of their remarkable forms and the certainty of their horizon, ought to be especially noted. The Brachiopods are here represented by *Spiriferina* and *Rhynchonella*, abounding in individuals, and above all by the *Waldheimia cor*, Lamk., a species of the highest importance. The Echinoderms are in general few in number and species, but *Pentacrinus tuberculatus* is inferior to no other fossil in the zone for its importance and the number of its individuals. The following list gives the characteristic fossils of the zone of *Ammonites oxynotus* as defined by M. Dumortier:

CEPHALOPODA.

Belemnites acutus, *Mill.*
Nautilus pertextus, *Dumort.*
Ammonites resurgens, *Dumort.*
— Hartmanni, *Oppel.*
— Berardi, *Dumort.*
— Patti, *Dumort.*
— lacunatus, *Buck.*
— obtusus, *Sow.*
— stellaris, *Sow.*
Ammonites Œduensis, *Pharmasse.*
— Landrioti, *d'Orb.*
— Locardi, *Dumort.*
— Birchii, *Sow.*
— Sauzeanus, *d'Orb.*
— Victoris, *Dumort.*
— Aballoensis, *d'Orb.*
— oxynotus, *Quenst.*
— altus, *Hauer.*

[1] 'Études Paléontologiques sur les Dépôts Jurassiques du Bassin du Rhône,' tom. ii, p. 238, 1867.

Ammonites Driani, *Dumort.*
— Salisburgensis, *Hauer.*
— Sæmanni, *Dumort.*
— Bonnardi, *d'Orb.*
— Nodotianus, *d'Orb.*
— Pellati, *Dumort.*
— armentalis, *Dumort.*
— Edmondi, *Dumort.*

Ammonites Oosteri, *Dumort.*
— planicosta, *Sow.*
— subplanicosta, *Oppel.*
— tardecrescens, *von Hauer.*
— viticola, *Dumort.*
— raricostatus, *Ziet.*
— vellicatus, *Dumort.*
— ziphus, *Hehl.*

Gasteropoda.

Pleurotomaria gigas, *Deslong.*

Pleurotomaria Charmassei, *Dumort.*

Conchifera.

Pleuromya Toucasi, *Dumort.*
— cylindrica, *Dumort.*
Hippopodium ponderosum, *Sow.*
Gryphæa obliqua, *Goldf.*

Myoconcha oxynoti, *Quenst.*
Harpax nitidus, *Dumort.*
Waldheimia cor, *Lamk.*
Terebratula Sinemuriensis, *Opp.*

M. Dumortier includes in his zone of *Ammonites oxynotus* many species already enumerated in my description of the *Obtusus*- and *Raricostatus*-zones; it is well, therefore, to understand this author's definition of the group he has so well described and so fully illustrated. He says, "the superior part of the Lower Lias, which I comprehend under the name of the '*zone de l'Ammonites oxynotus*,' offers an ensemble of beds of a total inconsiderable thickness, but which may be represented by the following theoretical section, taking the beds in descending order from above downwards."[1]

Zones.	Petrology.	Thickness.	Palæontology.
		metres	
Couches à *Am. raricostatus.*	Calcareous beds, consisting of light-coloured limestones ...	1 0	*Am. raricostatus, A. planicosta, A. viticola, Cardinia philea.*
Couches à *Am. oxynotus.*	Subcrystalline calcareous beds, reddish, or brown-yellow compact limestone	1 50	*Am. oxynotus, A. Aballoensis, A. Driani, A. Bonnardi, Nautilus pertextus, Avicula Sinemuriensis.*
Couches à *Am. stellaris.*	Hard sublamellated greyish limestone.....	3 0	*Am. stellaris, A. Œduensis, A. obtusus, Gryphæa obliqua, Waldheimia cor.*
Couches à *Am. Davidsoni.*	Hard sublamellated bluish-grey limestone.....	1 50	*Am. Davidsoni, A. lacunatus, A. Hartmanni, Pentacrinus tuberculatus.*
	Total thickness	7 0	

It is evident from the above table that Dumortier's "*zone de l'Ammonites oxynotus*" comprehends the *Raricostatus*-, *Oxynotus*-, and *Obtusus*-beds of this Monograph.

The distribution of the Ammonites in this zone has been very carefully observed and noted by this author, and he has therefore called the special attention of palæontologists

[1] 'Études Paléontologiques sur les Dépôts Jurassiques du Bassin du Rhône,' tom. ii, p. 95, 1867.

to the subject by remarking "above all, the invariable regularity of the different horizons they occupy." He has further summarised his observations in the following table, which shows how the species are distributed vertically, and how each of the four stages of life is characterised by a certain number of species.

These observations on Ammonite-zones made by so careful and thoughtful a student of Liassic palæontology as Dumortier proved himself to be, I commend to the consideration of all those who doubt the value of such divisions of the Secondary rocks which I have maintained and followed out in this and other memoirs during the last twenty years.

Distribution of Ammonites in the Zone of Ammonites oxynotus, after Dumortier.

Beds with Am. Davidsoni.	Beds with Am. stellaris.	Beds with Am. oxynotus.	Beds with Am. raricostatus.
Am. Davidsoni	*Am. stellaris*	*Am. oxynotus*	*Am. planicosta*
— *resurgens*	— *obtusus*	— *Victoris*	— *raricostatus*
— *Hartmanni*	— *Œduensis*	— *Aballoensis*	— *Cluniacensis*
— *Berardi*	— *Landrioti*	— *Buvigneri*	— *jejunus*
— *Patti*	— *Locardi*	— *Greenoughi*	— *Nodotianus*
— *lacunatus*	— *Birchii*	— *tamariscinus*	— *Pellati*
— *Sauzeanus*	— *semicostatus*	— *altus*	— *Pauli*
— *Scipionianus*	— *Boucaultianus*	— *Driani*	— *armentalis*
— *spiratissimus*	— *Guibalianus*	— *Salisburgensis*	— *subplanicosta*
		— *Sœmanni*	— *tardecrescens*
		— *Bonnardi*	— *viticola*
		— *Dudressieri*	— *vellicatus*
		— *Ziphus*	— *Edmundi*
		— *Bodleyi*	— *Oosteri*

In this table the two lowest zones have nine, and the two uppermost fourteen, species in each. In the *Davidsoni*-beds *Aeg. Davidsoni* and *Aeg. Berardi* have affinities with *Aeg. planorbis; Arietites Sauzeanus, Ar. Scipionianus, Ar. resurgens,* and *Ar. Hartmanni* with *Arietites bisulcatus; Ar. spiratissimus* with *Ar. Conybeari;* and *Aeg. lacunatum* with *Aeg. Charmassei,* from which it is derived.

In the *Stellaris*-beds *Aeg. Œduensis* has affinities with *Aeg. Johnstoni; Aeg. Locardi,* with *Aeg. Birhii; Aeg. Boucaultianum,* with *Aeg. Charmassei; Amal. Guibalianus,* with *Amal. Aballoensis;* whilst *Ar. obtusus, Ar. stellaris,* and *Ar. semicostatus* are the expiring forms of the genus *Arietites.*

The *Oxynotus*-beds are characterised by new types of Ammonite life belonging to the genus *Amaltheus,* which now appear for the first time as *Amal. oxynotus, Amal. Victoris, Amal. Aballoensis, Amal. Greenoughi, Amal. Buvigneri,* and *Aeg. planicosta* = *ziphus* = *Dudressieri,* which last are morphological conditions of one species *Aeg. planicosta.*

The *Raricostatus*-beds are characterised by forms which depart from the Arietites type; they have a wide umbilicus, narrow whorls, and were slowly developed as *Ar. Nodotianus, Ar. viticola, Ar. vellicatus, Ar. Edmundi,* which are all nearly allied to *Ar. raricostatus.*

The Lias Fishes from Lyme Regis.

I have stated (p. 48) that I have no authentic observations nor reliable notes on the stratigraphical distribution of the Fossil Fishes obtained at Lyme Regis from the Lias beds of the coast by the workmen, who have carefully kept their secret for their own advantage. Still, as most of these Ichthyolites were collected from the Lower Lias, and chiefly, I understand, from the Bucklandi- and Turneri-beds, I am unwilling to allow such an important gap to remain a blank in my otherwise complete lists of the Fauna of this classical region; and so I applied to my friend Sir Philip de Malpas Grey-Egerton, Bart., F.R.S., the highest living authority on Fossil Ichthyology, to prepare a list of the Fossil Fishes of the Lyme Lias beds. With his uniform courtesy and kindness Sir Philip has complied with my request, and I have now the pleasure of adding to my work his important addition, for which I return my very best thanks.

Alphabetical Catalogue of Fossil Fishes found in the Lias at Lyme Regis, with references to the authorities for the names and descriptions. By Sir Philip de Malpas Grey-Egerton, Bart., M.P., F.R.S., G.S., &c.

Acrodus, *Agassiz.*		
—	Anningiæ, *Ag.*	Poissons Fossiles, vol. iii, p. 175.
—	gibberulus, *Ag.*	Id., vol. iii, p. 144.
—	latus, *Ag.*	Id., vol. iii, p. 144.
—	nobilis, *Ag.*	Id., vol. iii, p. 140.
—	undulatus, *Ag.*	Id., vol. iii, p. 144.
Æchmodus, *Egerton* (Tetragonolepis, *Agassiz*).		
—	confluens, *Ag.*	Id., vol. ii, p. 199.
—	heteroderma, *Ag.*	Id., vol. ii, p. 206.
—	Leachii, *Ag.*	Id., vol. ii, p. 203.
—	leiosomus, *Ag.*	Id., vol. ii, p. 202.
—	pholidotus, *Ag.*	Id., vol. ii, p. 207.
—	pustulatus, *Ag.*	Id., vol. ii, p. 201.
—	radiatus, *Ag.*	Id., vol. ii, p. 201.
—	speciosus, *Ag.*	Id., vol. ii, p. 199.
Amblyurus, *Agassiz.*		
—	macrostomus, *Ag.*	Id., vol. ii, p. 220.

ARTHROPTERUS, *Agassiz.*

— Rileyi, *Ag.* Poissons Fossiles, vol. iii, p. 379.

BELONOSTOMUS *Agassiz* (Belonorhynchus, *Bronn*).

— Anningiæ, *Ag.* Id., vol. ii, part 2, p. 143.

— tenellus, *Ag.*, doubtful, probably B. Anningiæ.

CATURUS, *Agassiz.*

— Bucklandi, *Ag.* Id., vol. ii, part 2, p. 119.

CENTROLEPIS, *Egerton.*

— asper, *Eg.* Mem. Geol. Surv., decade 9, pl. v.

CHONDROSTEUS, *Agassiz:*

— acipensiroides, *Ag.* Poissons Fossiles, vol. ii, part 2, p. 280.

— crassior, *Eg.* Phil. Trans., 1858.

— pachyurus, *Eg.* Id., 1858.

CONODUS, *Agassiz.*

— ferox, *Ag.* Poissons Fossiles, vol. ii, part 2, p. 105.

CYCLARTHRUS, *Agassiz.*

— macropterus, *Ag.* Id., vol. iii, p. 382.

DAPEDIUS, *De la Beche.*

— arenatus, *Ag.* Id., vol. ii, p. 304.

— Colei, *Ag.* Id., vol. ii, p. 195.

— granulatus, *Ag.* Id., vol. ii, p. 190.

— politus, *De la Beche.* Geol. Trans., ser. ii, vol. i, plate vi; Poissons Fossiles, vol. ii, p. 185.

— punctatus, *Ag.* Poissons Fossiles, vol. ii, p. 192.

ENDACTIS, *Agassiz.*

— Agassizi, *Eg.* Mem. Geol. Surv., decade 9, pl. iv.

EUGNATHUS, *Agassiz.*

— chirotes (Conodus, *Ag.*). Poissons Fossiles, vol. ii, part 2, p. 102.

— leptodus, *Ag.* Id., vol. ii, part 2, p. 105.

— mandibularis, *Ag.* Id., vol. ii, part 2, p. 105.

— minor, *Ag.* Id., vol. ii, part 2, p. 103.

— opercularis, *Ag.* Id., vol. ii, part 2, p. 104.

— ornatus, *Ag.* Id., vol. ii, part 2, p. 105.

— orthostomus, *Ag.* Id., vol. ii, part 2, p. 98.

— Philpotæ, *Ag.* Id., vol. ii, part 2, p. 101.

— polyodon, *Ag.* (Platysiagum, *Eg.*) Id., vol. ii, part 2, p. 104.

— scabriusculus, *Ag.* Id., vol. ii, part 2, p. 105.

— speciosus, *Ag.* Id., vol. ii, part 2, p. 100.

HARPACTIRA, *Egerton.*

— velox, *Eg.* Geol. Mag., 1876, p. 441.

HETEROLEPIDOTUS, *Egerton* (Lepidotus, *Ag.*).

— latus (Lepidotus fimbriatus, *Ag.*). Poissons Fossiles, vol. ii, p. 247; Mem. Geol. Surv., decade 13, pl. ii.

— sauroides, *Eg.* Mem. Geol. Surv., decade 13, pl. iii.

HOLOPHAGUS, *Egerton.*

— gulo, *Eg.* Id., dec. 10, p. 19, and dec. 13, pl. x.

HYBODUS, *Agassiz.*

— carinatus, *Ag.* Poissons Fossiles, vol. iii, p. 52.

— crassispinus, *Ag.* Id., vol. iii, p. 48.

— curtus, *Ag.* (Hybodus reticulatus, 2nd spine). Id., vol. iii, p. 50.

— De-la-Bechei, *Charlesworth.* Mag. Nat. Hist., 1839, p. 242.

— ensatus, *Ag.* Poissons Fossiles, vol. iii, p. 51.

— formosus, *Ag.* Id., vol. iii, p. 51.

— medius, *Ag.* Id., vol. iii, p. 184.

— pyramidalis, *Ag.* Id., vol. iii, p. 182.

— reticulatus, *Ag.* Id., vol. iii, pp. 50 and 180.

ISCHYODUS, *Egerton* (Chimæra, *Ag.*).

— Johnsoni, *Ag.* (Prognathodus, *Eg.*). Id., vol. iii, p. 344; Journ. Geol. Soc., 1872, p. 233.

— orthorhinus, *Eg.* Journ. Geol. Soc., 1871, pl. xiii.

ISOCOLUM, *Egerton.*

— granulatum, *Eg.* Id., 1868; Mem. Geol. Surv., decade 13, pl. iv.

LEPIDOTUS, *Agassiz.*

— rugosus, *Ag.* (Heterolepidotus, *Eg.* ?). Poissons Fossiles, vol. ii, p. 246.

— undatus, *Ag.* — Id., vol. ii, p. 245.

LEPTACANTHUS, *Agassiz.*

— tenuispinus, *Ag.* Id., vol. iii, p. 27.

LEPTOLEPIS, *Agassiz.*

— Bronni, *Ag.* Id., vol. ii, part 2, p. 133.

— caudalis, *Ag.* Id., vol. ii, part 2, p. 133.

MYRIACANTHUS, *Agassiz.*

— granulatus, *Ag* Id., vol. iii, p. 40.

— paradoxus, *Ag.* Id., vol. iii, p. 38.

— retrorsus, *Ag.* Id., vol. iii, p. 39.

NOTHOSOMUS, *Agassiz.*

— octostychius, *Ag.* Id., vol. ii, part 2, p. 221; Mem. Geol. Surv., dec. 9, p. 6.

Osteorachis, *Egerton*.
— macrocephalus, *Eg.* Mem. Geol. Surv., dec. 13, pl. v.
Oxygnathus, *Egerton*.
— ornatus, *Eg.* Id., dec. 8, pl. ix.
Pachycormus, *Agassiz*.
— branchialis, *Ag.* MS.
— heterurus, *Ag.* Poissons Fossiles, vol. ii, part 2, p. 113.
— latipennis, *Ag.* Mem. Geol. Surv., dec. 9, pl. iii.
— macrurus, *Ag.* Poissons Fossiles, vol. ii, part 2, p. 113.
Palæospinax, *Egerton* (Thyellina, *Agassiz*.)
— priscus, *Ag.* Mem. Geol. Surv., dec. 13, pl. vii.
Pholidophorus, *Agassiz*.
— Bechei, *Ag.* Poissons Fossiles, vol. ii, p. 272.
— crenulatus, *Eg.* Mem. Geol. Surv., dec. 6, pl. v.
— latiusculus, *Ag.* Poissons Fossiles, vol. ii, p. 287.
— limbatus, *Ag.* Id., vol. ii, p. 282.
— onychius, *Ag.* Id., vol. ii, p. 274.
— pachysomus, *Eg.* Mem. Geol. Surv., dec. 6, pl. iv.
Platysiagum, *Egerton*.
— sclerocephalum, *Eg.* Id., dec. 13, pl. vi.
Prognathodus, *Egerton*.
— Güntheri, *Eg.* Journ. Geol. Soc., 1872, p. 233.
Ptycholepis, *Agassiz*.
— Bollensis, *Ag.* Poissons Fossiles, vol. ii, pt. 2, p. 108.
— curtus, *Eg.* Mem. Geol. Surv., dec. 8, pl. viii.
Semionotus, *Agassiz*.
— rhombifer, *Ag.* (Heterolepidotus? *Eg.*). Poissons Fossiles, vol. ii, p. 228.
Squaloraia, *Riley* (Spinacorhinus, *Agassiz*).
— polyspondyla, *Riley*. Poissons Fossiles, vol. iii, p. 379.
Thrissonotus, *Agassiz*.
— Colei, *Ag.* Id., vol. ii, part 2, p. 128; Mem. Geol. Surv., dec. 2, pl. ii.

After a comparison of my original notes on the Lyme sections with a stratigraphical table in manuscript of the same beds, made by my friend Mr. Etheridge, F.R.S., which he has kindly allowed me to examine, I find we are in perfect accordance on the position of the Ichthyolites. Few remains of this class are found in the *Angulatum*-zone. The dark marls of the *Bucklandi*- and *Turneri*-beds appear to be the chief repositories of the Lyme Lias Fishes, as already indicated in my sections at pp. 38, 48,

and 50. A few specimens of *Æchmodus* were found in the marls above the Belemnite-beds at Golden Cap, but few remains are known in other beds of the Middle Lias.

A Table showing the extension of the Lower Lias in the British Islands, Belgium, France, Switzerland, Germany, Austria, and Italy, with indications of the Sinemurian Ammonite Zones, found in some typical regions of the European area.

Ammonite Zones of the Lower Lias.	British Islands.			Belgium.	France.				Switzerland.	Germany.		Austria.	Italy.
	England.	Ireland.	Scotland.	Luxemburg.	Côte-d'Or.	Yonne.	Moselle.	Jura.	Basel.	Hanover.	Württemberg.	N. E. Alps.	Tuscany.
RARICOSTATUS	*	*	...	...	*	*	...	*	*	*	*	*	*
OXYNOTUS	*	...	...	...	*	*	...	*	*	...	*	*	...
OBTUSUS	*	...	...	*	*	*	...	*	*	*	*	*	*
TURNERI	*	...	...	*	*	*	*	*	*	...	*	...	*
BUCKLANDI	*	*	*	*	*	*	*	*	*	*	*	*	*
ANGULATUM	*	*	...	*	*	*	*	*	*	*	*	*	*
PLANORBIS	*	*	...	*	*	*	*	*	*	*	*	*	...
AVICULA CONTORTA	*	*	...	*	*	*	*	*	*	*	*	*	*

My learned friend, Professor Edward Suess, of Vienna, whose valuable and suggestive memoir "Über die Ammoniten"[1] formed the basis of the new generic classification of Ammonites, writes to me, "we have now discovered a number of Ammonite horizons only a few inches in thickness, as for example the *Aeg. planorbis* 18 inches, *Aeg. angulatum* 20—36 inches, upon thousands of feet of Rhætic deposits in the midst of our Alps. This contiguity of single horizons surely gives the Jurassic formation, or at least a part of it, a character rather different from other European deposits, and well worth the exact analogies which you offer."

[1] 'Sitzungsber. d. k. Akad. d. Wissensch.,' Bd. lii, Sitzung vom 30 Juin, 1865.

A Table showing the stratigraphical distribution of the Ammonoida in the Lower Lias zones of the British Islands.

Families, Genera, and Species.	Planorbis-zone.	Angulatum-zone.	Lower Bucklandi-zone.	Upper Bucklandi-zone.	Turneri-zone.	Obtusus-zone.	Oxynotus-zone.	Raricostatus-zone.
Family—AEGOCERATIDÆ.								
Genus—AEGOCERAS.								
Aegoceras planorbis, *Sow.*	*	...	...	...	...	...	...	...
Johnstoni, *Sow.*	*	*	...	...	...	...	...	...
Liassicum, *d'Orbig.*	...	*	...	...	...	...	...	...
angulatum, *Schloth.*	...	*	...	...	...	...	...	...
catenatum, *De la Beche*	...	*	...	...	...	...	...	...
tortile, *d'Orbig.*	...	*	...	...	...	...	...	...
Charmassei, *d'Orbig.*	...	...	*	...	..	...	...	...
Boucaultianum, *d'Orbig.*	...	...	...	*	...	...	...	...
Birchii, *Sow.*	...	...	...	*	...	...	...	...
planicosta, *Sow.*	...	...	...	*	...	...	...	...
sagittarium, *Blake*	...	...	...	...	...	...	*	...
gagateum, *Young & Bird*	...	...	...	...	...	...	*	...
subplanicosta, *Opp.*	...	...	...	...	...	...	...	*
Genus—ARIETITES.								
Arietites Bucklandi, *Sow.*	...	...	*	...	...	...	...	...
bisulcatus, *Brug.*	...	...	*	...	...	...	...	...
multicostatus, *Sow.*	...	...	*	...	...	...	...	...
Conybeari, *Sow.*	...	...	*	...	...	...	...	...
rotiformis, *Sow.*	...	...	*	...	...	...	...	...
spiratissimus, *Quenst.*	...	...	...	*	...	...	...	...
obesulus, *Blake* = resurgens, *Dumort.*	...	...	...	*	...	...	...	...
Scipionianus, *d'Orbig.*	...	...	...	*	...	...	...	...
Sauzeanus, *d'Orbig.*	...	...	...	*	...	...	...	...
Crossii, *Wright.*	...	...	...	*	...	...	...	...
semicostatus, *Young & Bird*	...	...	...	*	*	...	...	...
Turneri, *Sow.*	...	...	...	...	*	...	...	...
Bonnardii, *d'Orbig.*	...	...	...	...	*	...	...	...
stellaris, *Sow.*	...	...	...	...	...	*	...	...
obtusus, *Sow.*	...	...	...	...	...	*	...	...
raricostatus, *Ziet.*	...	...	...	...	...	...	...	*
Nodotianus, *d'Orbig.*	...	...	...	...	...	...	...	*
Family—ARCESTIDÆ.								
Genus—AMALTHEUS.								
Amaltheus oxynotus, *Quenst.*	...	...	...	...	...	...	*	...
Lymensis, *Wright*	...	...	...	...	...	...	*	...
denotatus, *Simpson*	...	...	...	...	...	...	*	...
impendens, *Young & Bird*	...	...	...	...	...	...	*	...
Simpsoni, *Bean.*	...	...	...	...	...	...	*	...
Oppeli, *Schlönb.*	...	...	...	...	...	...	*	...

THE MIDDLE LIAS.

The Middle Lias is well developed in England, and fully exposed in the grand natural sections of the Yorkshire and Dorsetshire coasts. In the Midland Counties some of the zones are only partially shown. I have therefore selected a section of the cliffs east of Charmouth, Dorset, which I made for this work many years ago, as one that affords a good general view of the whole, and at the same time shows the relation of its *spinatus*-bed to the Upper Lias which rests conformably upon it; the Middle Lias here attains a thickness of about 450 feet, and is divisible into five stages, each characterised by well-determined Ammonite forms. In ascending order these are—1st. The zone of *Aegoceras Jamesoni*. 2nd. The zone of *Amaltheus Ibex*. 3rd. The zone of *Aegoceras Henleyi*. 4th. The zone of *Amaltheus margaritatus*. 5th. The zone of *Amaltheus spinatus*.

Section of Down Cliffs, at Toad's Cove, near Bridport Harbour.

Upper Lias.

Altitude.	No.	Lithology.	Thickness.	Organic Remains.
ft.			ft.	
400	1	Zone of Harpoceras opalinum.		*Harpoceras opalinum*, Rein., at Burton Cliff, and Chideock Hill.
		Zone of Lytoceras Jurense.		
	2	Brown sands, sometimes micaceous, with large sandstone nodules in layers	70	*Harpoceras variabile*, d'Orb. *Harpoceras insigne*, Schlüb.
		Zone of Harpoceras bifrons.		
300	3	Dark-greyish sandy marl, very micaceous.....	72	*Harpoceras bifrons*, Brug., *Pleuromya unioides*, Roem. Fossils rare, and often indeterminable.
		Zone of Harpoceras serpentinum.		
	4	Brownish marly limestone, containing great numbers of *Harpoceras serpentinum* and Upper Lias shells. The Middle Lias comes up to the lower part of this band of stone, with *Amaltheus spinatus* embedded therein	2½	*Harpoceras serpentinum*, Schlot., *Stephanoceras commune*, Sow., *S. Raquinianum*, d'Orb., *Venus pumila*, Münst., *Rhynch. acuta*, Sow., and *Rhynch. Moorei*, Dav.

Middle Lias.

Altitude.	No.	Lithology.	Thickness.	Organic Remains.
ft.			ft.	
		Zone of Amaltheus spinatus.		
	4	Dark-grey, sandy, micaceous marl	18	*Amaltheus spinatus*, Brug. *Belemnites breviformis*, Ziet.
	5	Indurated sand, forming large sandstone blocks	8	
	6	Light-brown sands, moré or less indurated, and very micaceous	56	No fossils found to enable us to determine whether the bed belongs to this, or the lower zone.
200		Zone of Amaltheus margaritatus.		
	7	Bluish marl, which forms a well-defined band in the section	6—8	
	8	Greyish, sandy, laminated marls, with irregular layers of nodules	20	*Amaltheus margaritatus*, Mont., *Lytoceras fimbriatum*, Sow., *Belemnites elongatus*, Mill., *Pleurotomaria similis*, Sow., *Cryptænia expansa*, Sow., *Pleuromya unioides*, Roem., *Pecten æquivalvis*, Sow., *Limea acuticosta*, Münst., *Pinna Hartmanni*, Münst., *Rhynchonella acuta*, Sow., *R. tetrahedra*, Sow., *R. calcicosta*, Quenst., *Gryphæa gigantea*, Sow.
	9	Foxy coloured sandstone, with from 12—16 irregular bands of stone forming the "rough bed" of the workmen	40	
	10	Band of Crinoidal limestone		*Pentacrinus subangularis*, Mill.
	11	Grey sandy clay, in parts micaceous ...	20	
100		Band of ferruginous septaria.		
	12	Grey laminated sandy clay	17	
	13	The "Starfish Bed," hard, grey, micaceous sandstone: large blocks from this bed lie on the shore	6	*Ophioderma Egertoni*, Brod., *Lytoceras fimbriatum*, Sow., *Amaltheus margaritatus*, Mont., *Belemnites elongatus*, Mill.
		Zone of Aegoceras Henleyi.		
	14	Grey marls, breaking up into cuboidal masses; in the upper part are several rows of small, fossiliferous nodules; this bed is much thicker, and better seen at Golden Cap	76	*Aegoceras Henleyi*, Sow., *Aeg. Bechei*, Sow., *Aeg. striatum*, Rein., *Aeg. planicosta*, Sow., *Aeg. Davœi*, Sow.
		Base of Down Cliffs.....		
		Zone of Aegoceras Jamesoni.		

The grey or micaceous marls attain a great thickness at Golden Cap, where they rest on the Belemnite-bed. These marls contain several stages of life, which have not been worked out with sufficient accuracy to enable me to define the limits of the different zones. Fragments of *Aegoceras Jamesoni* and *Aeg. submuticum* have been collected in the lower part of this deposit, and *Aegoceras Davœi*, *Henleyi*, and *Bechei*, in the upper.

In Gloucestershire, beneath the zone of *Aegoceras Henleyi*, two other zones are characterised by *Amaltheus Ibex* and *Aegoceras Jamesoni*, and these are probably comprised in the grey, micaceous marls at Golden Cap, which here attain so great a thickness.

8. The Zone of Aegoceras Jamesoni.

Synonyms.—"Micaceous marl," in part, De la Beche's section. "Numismalismergel oder Belemnitenmergel," Quenstedt, 'das Flötzgebirge Württembergs,' 1843. "Die Schichten des *Ammonites Jamesoni*," Oppel, 'Die Juraformation,' p. 118, 1856. "Lias Gamma," pars, Quenst., 'Der Jura Uebersichtstafel,' p. 293, 1858. "Jamesoni-bed," Wright, 'Quart. Jour. Geol. Soc.,' vol. xvi, p. 25, 1858. "Die Schichten des *Amm. Jamesoni*," Brauns, 'Untere Jura,' p. 100, 1871. "Zone of *Ammonites Jamesoni*," Tate and Blake, 'Yorkshire Lias,' p. 78, 1876.

Gloucestershire.—Upwards of twenty years ago I collected several fragments of the whorls of a large *Aegoceras Jamesoni* in some deep brick-pits near Leckhampton, which was the first evidence we had that this zone existed near Cheltenham. Since that time I have accumulated many of the leading fossils of the beds, and important additions have from time to time been made by Professor Tate, all of which are now recorded in the following list:

Cephalopoda.

Aegoceras armatum, *Sow.*
— brevispina, *Sow.*
— striatum, *Reinecke.*
— Henleyi, *Sow.*
— Loscombi, *Sow.*
— Jamesoni, *Sow.*
— Maugenesti, *d'Orb.*
— Valdani, *d'Orb.*
— pettos, *Quenst.*
Aegoceras Taylori, *Sow.*
Arietites Nodotianus, *d'Orb.*
Lytoceras fimbriatum, *Sow.*
Belemnites acuarius, *Schloth.*
— apicurvatus, *Blainv.*
— breviformis, *Voltz.*
— elongatus, *Sow.*
— Milleri, *Phill.*
— clavatus, *Schloth.*

Gasteropoda.

Cerithium armatum, *Münst.*
Chemnitzia Blainvillei, *Münst.*
— liassica, *Quenst.*
Cryptænia expansa, *Sow.*
Dentalium minimum, *Strick.*
— elongatum, *Münst.*
Phasianella paludinaria, *Münst.*
Trochus Thetis, *Münst.*

Lamellibranchiata.

Astarte striato-sulcata, *Röm.*
Avicula novemcostæ, *Brown.*
— substriata, *Münst.*
Cardinia crassissima, *Sow.*
Cypricardia cucullata, *Münst.*
Cucullæa Munsteri, *Goldf.*
Isocardia cingulata, *Goldf.*
Inoceramus ventricosus, *Sow.*
— substriatus, *Goldf.*
Leda acuminata, *Goldf.*
— Galatea, *d'Orb.*
Nucula cordata, *Goldf.*
Opis Carusensis, *d'Orb.*
Pecten liasinus, *Nyst.*
— acutiradiatus, *Goldf.*
— personatus, *Münst.*
Pholadomya decorata, *Hartm.*
Plicatula spinosa, *Sow.*
— alternans, *Deslong.*
Mytilus scalprum, *Sow.*
Pinna folium, *Y. & B.*
Gryphæa obliquata, *Sow.*
— cymbium, *Lamk.*
Limea acuticosta, *Goldf.*

Brachiopoda.

Discina Holdeni, *Tate*.
Rhynchonella variabilis, *Schloth*.
— furcillata, *Theod*.
— rimosa, *Theod*.
Spiriferina verrucosa, *von Buch*.
Terebratula punctata, *Sow*.
Waldheimia indentata, *Sow*.
— numismalis, *Schloth*.
— Waterhousei, *David*.
— subovoides, *Röm*.

Echinodermata.

Plumaster ophiuroides, *Wright*.
Pentacrinus basaltiformis, *Miller*.

Annelida.

Serpula plicatilis, *Goldf*.
Serpula tricristata, *Goldf*.

Yorkshire.—The Jamesoni-beds are found at the north side of Robin Hood's Bay, where the following important section was made by Messrs. Tate and Blake,[1] the thickness of the beds there amounting to 225 feet: the position of the fossils so carefully noted in each is of great value in reading correctly the Palæontology of this zone.

Jamesoni-beds, Robin Hood's Bay.

Base of the Henleyi-beds: the section to be read in a descending order.

No.	Lithology.	Thickness.	Organic Remains.
		ft. in.	
1	Hard, crumbly, light shale	5 0	
2	Dogger	0 6	
3	Shale	10 0	
4	Irregular dogger.		
5	Shale	4 0	
6	Brown sandy layer	0 3	
7	Shale	5 3	
8	Variable dogger	2 6	
9	Shale with indurated bands and nodules	13 6	*Aeg. striatum, Lytoceras fimbriatum, Ophioderma Gaveyi.*
10	Scattered dogger-band	1 0	
11	Shale	2 9	
12	Dogger	0 3	
13	Hard, crumbly shale	13 0	*Belemnites elegans.*
14	Dogger	0 6	
15	Bluer shale	2 0	
16	Dogger irregular.		
17	Bluer shale	7 0	*Aeg. brevispina*, Sow., *Gryphæa obliquata*, Sow., *Modiola scalprum*, Sow., *Pleuromya ovata*, Sow.
18	Well-marked dogger	0 3	*Belemnites elegans, Monotis inæquivalvis*, Sow.
19	Hard, grey, indurated shale, with more indurated band in the middle	11 6	*Pecten equivalvis*, Sow., *Limea acuticosta*, Münst., *Pinna folium*, Y. & B.
20	Dogger	0 3	
21	Blue shale	2 4	
22	Dogger	0 4	
23	Blue shale	5 0	*Gryphæa obliquata, Aeg. brevispina*, Sow.

[1] 'Yorkshire Lias,' pp. 79—81.

No.	Lithology.	Thickness. ft.	in.	Organic Remains.
24	Dogger	0	3	
25	Shale	1	10	*Pecten priscus*, Schl., *Chemnitzia Blainvillei*, Münst.
26	Regular dogger	0	6	
27	Shale	3	10	*Gresslya striata*, Agass., *Leda Galathea*, d'Orb., *Plicatula spinosa*, Sow., *Pinna folium*, Y. & B., *Belemnites araris*, Dumort., *Bel. virgatus*, Mayer.
28	Irregular dogger	0	6	
29	Shale	3	0	*Aeg. brevispina*, Sow., *Aeg. polymorphum*, Quenst., *Ditrypa circinata*, Tate.
30	Dogger	0	5	
31	Shale	1	0	
32	Dogger	0	5	*Modiola scalprum*, Sow.
33	Shale	14	8	*Amaltheus lynx, Aeg. polymorphum, Pleuromya ovata, Pholadomya decorata, Pecten priscus.*
34	Dogger	0	6	*Pholadomya decorata.*
35	Shale	5	4	*Pholadomya decorata.*
36	Dogger, irregular.			
37	Shale	4	3	*Pecten priscus*, Scloth., *Lima Hermanni*, Voltz.
38	Dogger, irregular.			
39	Shale	5	3	*Unicardium cardioide*, Phill.
40	Dogger, irregular.			
41	Shale	3	0	*Arcomya elongata, Pinna folium.*
42	Dogger, irregular			*Ditrypa circinata, Rhyn. plicatissima.*
43	Shale	4	0	*Pecten priscus, Gryphæa obliquata, Gresslya ovata.* Crustacean remains.
44	Dogger, strong	0	8	*Pinna folium.*
	This forms the base of the Jamesoni-beds proper.			
45	Blue shale	10	0	*Pinna folium, Cucullæa Münsteri, Limea acuticosta, Arcomya vetusta, Glyphæa Terquemi, Lima Hermanni.*
46	Ironstone dogger	0	8	
47	Blue shale, with pyritous nests full of fossils, about five feet down. Is at the base of the cliff, making the south point of the north cheek of the bay.	15	8	*Lima Hermanni, Monotis inæquivalvis, Gryphæa obliquata, Aeg. armatum, Aeg. Taylori, Pecten priscus, Protocardia oxynoti, Nucula contorta, Gresslya ovata, G. striata, Pleurotomaria procera, Spiriferina Walcotii, Rhynchonella calcicosta.*
48	Dogger	0	4	
49	Blue shale	12	0	
50	Band of rotted clay	0	2	
51	Ironstone dogger, well marked in the cliff	0	3	*Inoceramus ventricosus, Pecten calvus, Chemnitzia Blainvillei.*
52	Blue shale	5	0	
53	Strong ironstone dogger	0	4	*Gryphæa obliquata.*
54	Blue shale, with doggers and nests of fossils scattered	24	0	*Aeg. armatum, Pecten priscus, Belemnites clavatus, Ditrypa circinata.*
	Thin line of broken fossils	0	1	*Ammonites, Belemnites, Pecten, Cerithium.*
55	Blue shale field of Belemnites and Gryphæas	5	6	*Aeg. armatum, Aeg. planicosta, Belemnites, Gryphæa obliquata, Limea acuticosta, Pecten priscus, Cucullæa Münsteri, Pinna folium.*
56	Ironstone dogger	0	3	

No.	Lithology.	Thickness.	Organic Remains.
		ft. in.	
57	Blue shale	3 0	*Aegoceras armatum.*
58	Scattered irregular doggers and blue shale	3 0	*Ariet. tardecrescens, Pecten calvus, Pecten sub-Bestriatus, Cucullæa Münsteri.*
59	Argillaceous ironstone dogger with cone-in-cone structure at top	0 4	
60	Blue shale, estimated at	8 6	*Aeg. armatum, Ar. Macdonnelli = Nodotianus, Belemnites elegans, Pentacrinus, L. acuticosta.*
	Base of the *Armatum zone.*		
	Total thickness	225 8	

Warwickshire.—The Jamesoni and Ibex beds are developed at Fenny Compton, Warwickshire, where they have been carefully studied and well described by Mr. T. Beesley, F.C.S., of Banbury.[1] The rocks are about 100 feet in thickness, and the following section affords an idea of their petrology, thickness, and organic remains.

No.	Petrology.	Thickness.	Organic Remains.
		ft. in.	
1	Rough shaly clay	20 0	
2	Band of nodules, argillo-calcareous	0 2	
3	Shale	10 0	
4	Band of fossiliferous nodules	0 3	*Aeg. striatum, Amal. Ibex, Aeg. Maugenesti, Aeg. Valdani.*
5	Shale	8 0	
6	Band of fossiliferous nodules	0 2	*Aeg. Maugenesti,* Fucoids.
7	Belemnite shale	2 0	*Belemnites breviformis,* and several others.
8	Rough, shelly, argillaceous limestone, with numerous fossils	1 0	*Aeg. Jamesoni, Aeg. Valdani, Belemnites clavatus, Lima Hettangiensis, Spiriferina verrucosa, Waldheimia numismalis, Rhynchonella rimosa.*
9	Belemnite shale	4 6	*Belemnites clavatus, B. apicicurvatus.*
10	Rough, shelly, argillaceous limestone, with many fossils		*Aeg. armatum, Pecten priscus, Limea acuticostata, Gryphæa obliquata, Cardinia attenuata, Rhyn. rimosa, Montlivaltia mucronata.*
11	Shale	1 8	
12	Nodular band	0 3	
13	Shale	3 0	
14	Band of fossiliferous nodules	0 3	*Pecten calvus, Terebrat. punctata,* var. *Radstockiensis,* David.
15	Shale	14 0	
16	Band of nodules	0 2	
17	Shale	5 0	
18	Band of nodules	0 2	
19	Shale	3 6	
20	Band of nodules	0 2	
21	Shale	22 0	
		96 3	

[1] "Lias of Fenny Compton, Warwickshire." Reprinted from the 'Proceedings of the Warwickshire Nat. and Archæol. Field-Club,' p. 14, 1877.

List of Fossils from the Jamesoni Zone, Fenny Compton.

Vertebrata.

Ichthyosaurus, bones and teeth.

Fishes; vertebræ and other remains.

Cephalopoda.

Harpoceras arietiforme, *Oppel.*
Aegoceras armatum, *Sow.*
— biferum, *Quenst.*
— brevispina, *Sow.*
— Buvignieri, *d'Orb.*
— Centaurus, *d'Orb.*
— densinodum, *Quenst.*
— striatum, *Reinecke.*
— Ibex, *Quenst.*
— Maugenesti, *d'Orb.*
— Jamesoni, *Sow.*
— Loscombi, *Sow.*
— Lynx, *d'Orb.*
— pettos, *Quenst.*
— Valdani, *d'Orb.*
Lytoceras fimbriatum, *Sow.*
Belemnites acutus, *Mill.*
— apicicurvatus, *Blainv.*
— araris, *Dumort.*
— breviformis, *Voltz.*
Belemnites brevis, *Dumort.*
— Bucklandi *Phill.*
— calcar, *Phill.*
— Charmouthensis, *Mayer.*
— clavatus, *Blainv.*
— compressus, *Stahl.*
— cylindricus, *Simp.*
— elegans, *Simp.*
— elongatus, *Sow.*
— junceus ? *Phill.*
— lageniformis, *Ziet.*
— longiformis, *Blake.*
— longissimus, *Mill.*
— Milleri, *Phill.*
— oxynotus, *Quenst.*
— nitidus, *Phill.*
— palliatus, *Dumort.*
— penicillatus, *Sow.*
— ventroplanus, *Voltz.*
— virgatus, *Mayer.*

Gasteropoda.

Actæonina Ilminsterensis, *Moore.*
— marginata, *Simp.*
— numismalis, *Quenst.*
Tornatella capricornus, *Tate.*
Cerithium Camertonense, *Moore.*
— Brodiei, *Tate.*
— Ibex, *Tate.*
— Slatteri, *Tate.*
Chemnitzia Blainvillei, *Münst.*
— citharella, *Tate.*
— crassicosta, *Tate.*
— foviolata, *Tate.*
Dentalium angulatum, *Buck.*
— minimum, *Strick.*
Eucyclus Gaudryanus, *d'Orb.*
— imbricatus, *Sow.*
Pitonellus conicus, *d'Orb.*
— lineatus, *Moore.*
— turbinatus, *Moore.*
Pleurotomaria similis, *Sow.*
Cryptænia expansa, *Sow.*
Trochus limbatus, *Schloth.*
— Pandion, *Dumort.*
— Pluto, *d'Orb.*
— Thetis, *Goldf.*
Turbo admirandus, *Tate.*
— Lucilius, *d'Orb.*
Turritella anomala, *Moore.*

Lamellibranchiata.

Anomia numismalis, *Quenst.*
Arcomya elongata, *Römer.*
Astarte striato-sulcata, *Goldf.*
— Camertonensis, *Moore.*
— obsoleta, *Dunk.*
Avicula calva, *Schlönb.*
— inæquivalvis, *Sow.*
— papyria, *Quenst.*
Cardinia attenuata, *Stutch.*
Cardita multicostata, *Phill.*
Protocardia bombax, *Tate.*
— oxynoti, *Quenst.*
— truncata, *Sow.*
Ceromya bombax, *Quenst.*
— rugata, *Quenst.*
Cypricardia cucullata, *Münst.*
Cucullæa Münsteri, *Ziet.*
Gervillia lævis, *Buck.*
Goniomya hybrida, *Münst.*
Gresslya lunata, *Tate.*
— punctata, *Simp.*
— striata, *Agass.*
Gryphæa obliquata, *Sow.*
Harpax Parkinsoni, *Dumort.*
Hinnites tumidus, *Ziet.*
Hippopodium ponderosum, *Sow.*
Leda complanata, *Goldf.*
— Galathea, *d'Orb.*
— graphica, *Tate.*
— minor, *Simp.*
— subovalis, *Goldf.*
Leda Zieteni, *Brauns.*
— acuminata, *Ziet.*
Lima eucharis, *d'Orb.*
— Hettangiensis, *Terq.*
— Hermanni, *Voltz.*
— punctata, *Sow.*
— pectinoides, *Sow.*
— scabricula, *Tate.*
Limea acuticosta, *Goldf.*
Macrodon intermedium, *Simp.*
Modiola numismalis, *Oppel.*
— scalprum, *Sow.*
Myoconcha decorata, *Münst.*
Nucula cordata, *Goldf.*
Ostrea Goldfussi, *Brauns.*
— semiplicata, *Römer.*
Pecten acuticostatus, *Lam.*
— acutiradiatus, *Goldf.*
— calvus, *Goldf.*
— fortunatus, *Dumort.*
— liasinus, *Nyst.*
— priscus, *Schloth.*
— substriatus, *Röm.*
— textorius, *Schloth.*
Pholadomya ambigua, *Sow.*
— decorata, *Hartm.*
Pinna folium, *Young & Bird.*
Pleuromya ovata, *Römer.*
Plicatula sarcinula, *Goldf.*
— spinosa, *Sow.*
Unicardium cardioides, *Phill.*

Brachiopoda.

Discina Holdeni, *Tate.*
Lingula sacculus, *Chap. & Dewal.*
Rhynchonella calcicosta, *Quenst.*
— furcillata, *Théod.*
— rimosa, *Théod.*
— subconcinna, *David.*
— tetraëdra, *Sow.*
Spiriferina oxyptera, *Bur.*
Spiriferina pinguis, *Tiet.*
— Walcotii, *Sow.*
Terebratula Radstockensis, *Dav.*
— punctata, *Sow.*
Waldheimia indentata, *Sow.*
— numismalis, *Lamk.*
— Sarthacencis, *d'Orb.*
— perforata, *Piette.*

Polyzoa.

Alecto dichotoma, *Goldf.*
Stromatopora antiqua, *Terq. & Piet.*

Crustacea.

Bairdia dispersa, *Blake.*
— liassica, *Bl.*
Polycope cerasia, *Bl.*
Cythere Redcarensis, *Bl.*
— translucens, *Bl.*
Cythere triangulata, *Bl.*
Glyphæa, *sp.*
Pseudoglyphæa, *sp.*
Eryma lævis, *Bl.*

Annelida.

Galeolaria socialis, *Goldf.*
Ditrypa circinata, *Tate.*
— Etalensis, *Piette.*
— globiceps, *Quenst.*
— quinquesulcata, *Goldf.*
Serpula limax, *Goldf.*
— plicatilis, *Goldf.*
— tricristata, *Goldf.*
— mundula, *Dumort.*

Echinodermata.

Cidaris Edwardsii, *Wright.*
Ophioderma Gaveyi, *Wright*
Extracrinus subangularis, *Mill.*
Millericrinus Hausmanni, *Röm.*
Pentacrinus basaltiformis, *Mill.*
— Milleri, *Austin.*
— scalaris, *Quenst.*
— punctiferus, *Quenst.*

Anthozoa.

Montlivaltia mucronata, *Dunc.*
— rugosa, *Wright.*
Montlivaltia nummiformis, *Dunc.*
— radiata, *Dunc.*

Foraminifera.

Cristellaria matutina, *Terq.*
— recta, *d'Orb.*
— rustica, *Terq.*
Dentalina irregularis, *Terq.*
— nodosa, *d'Orb.*
— pauperata, *d'Orb.*
— perlucida, *Terq.*
— quadrilatera, *Terq.*
— striata, *Terq.*
— torta, *Terq.*
Flabellina rugosa, *d'Orb.*
Frondicularia sulcata, *Born.*
— Terquemi, *d'Orb.*
Glandulina conica, *Terq.*
Lagena, *sp.*
Lingulina tenera, *Born.*
Marginulina 12-costata, *Terq.*
— interlineata, *Terq.*
— prima, *var.* acuta, *Terq.*
Miliola, *sp.*
Nodosaria nitida, *d'Orb.*
— raphanistrum, *Linn.*
— raphanus, *Linn.*
— Simoniana, *Terq.*
Orbulina universa, *Terq.*
Polymorphia nodosaria, *Reuss.*
Spiroloculina, *sp.*
Trochammina gordialis, *P. & J.*

This rich fauna of the Jamesoni-beds at Fenny Compton has been collected by Mr. Beesley, F.C.S., of Banbury, and forms part of his valuable collection of Lias fossils.

The Middle Lias has been shown by Professor Ralph Tate,[1] F.G.S., to be well developed near Radstock, and he has ascertained the existence of the *Jamesoni*, *Ibex*,

[1] 'Quart. Journ. Geol. Soc.,' vol. xxxi, p. 500.

and *Henleyi* beds in the Munger Quarry, near Paulton, Somersetshire. The *Jamesoni*-bed here consists of a soft, yellow, ironshot limestone, indistinctly bedded, rather lumpy, and very fossiliferous, and from this and the upper beds the following fauna was collected. In consequence of the thinning out of the Lias strata in this locality the three zones are comprised within three yards of rock.

Fossils from the Jamesoni-beds of the Radstock District.

Cephalopoda.

Aegoceras Henleyi, *Sow.*
— Maugenesti, *d'Orb.*
— Jamesoni, *Sow.*
— armatum, *Sow.*
— striatum, *Reinecke.*
— Buvignieri, *d'Orb.*
— pettos, *Quenst.*
Aegoceras brevispina, *Sow.*
— polymorphum, *Quenst.*
Lytoceras fimbriatum, *Sow.*
Amaltheus Ibex, *Quenst.*
Nautilus intermedius, *Sow.*
Belemnites clavatus, *Schloth.*
— elongatus, *Mill.*

Gasteropoda.

Dentalium elongatum, *Münst.*
Cryptænia expansa, *Sow.*
— heliciformis, *Deslong.*
Pleurotomaria granosa, *Schloth.*
Turbo cyclostoma, *Ziet.*
— Socconensis, *d'Orb.*
— bullatus, *Moore.*
Pitonellus conicus, *d'Orb.*
Phasianella turbinata, *Stoliczka.*
Trochus acutus, *Schloth.*
— mammillaris, *Moore.*
— Thetis, *Goldf.*
— limbatus, *Schloth.*
— Ægion, *d'Orb.*
Eucyclus Guadryanus, *d'Orb.*
Chemnitzia undulata, *Ziet.*
— Blainvillei, *Gold.*
Actæonina marginata, *Simp.*

Lamellibranchiata.

Ostrea simplicata, *Münst.*
Pecten lunularis, *Römer.*
— priscus, *Schloth.*
— substriatus, *Römer.*
Hinnites tumidus, *Ziet.*
Lima Hermanni, *Ziet.*
— Hettangiensis, *Terq.*
— eucharis, *d'Orb.*
Limea acuticosta, *Goldf.*
Plicatula spinosa, *Sow.*
Avicula longiaxis, *Buck.*
Inoceramus ventricosus, *Sow.*
Pinna folium, *Young & Bird.*
Macrodon Buckmani, *Richard.*
Macrodon intermedium, *Simp*
Nucula cordata, *Goldf.*
Leda Galathea, *d'Orb.*
Cardita consimilis, *Tate.*
Astarte striato-sulcata, *Goldf.*
— Camertonensis, *Moore*
Myoconcha decorata, *Goldf.*
Cypricardia cucullata, *Goldf.*
Cardinia attenuata, *Stutch.*
— crassissima, *Sow.*
— concinna, *Sow.*
Ceromya bombax, *Quenst.*
Pleuromya ovata, *Röm.*
Pholadomya ambigua, *Sow.*

Brachiopoda.

Waldheimia indentata, *Sow.*
— numismalis, *Lamk.*
— Waterhousei, *David.*
— cornuta, *Sow.*
Terebratula punctata, *Sow.*
— Edwardsi, *David.*
— subovoides, *Röm.*
Spiriferina rostrata, *Schloth.*
Rhynchonella furcillata, *von Buch.*
— rimosa, *von Buch.*
— variabilis, *Schloth.*
Thecidea Bouchardi, *David.*
Leptæna rostrata, *David.*
— Bouchardi, *David.*

The Hebridean Jura.—More than twenty years ago my friend Professor A. Geikie,[1] F.R.S., made a collection of Lias fossils from the islands of Skye, Scalpa, Pabba, Raasay, &c., which he sent to me to examine and determine. Most of the specimens were collected from the dark brown micaceous shales of Pabba, beyond Corry, and around the syenite of Beinn Bhindh, as far as the entrance to Scalpa Sound. These specimens were carefully studied and compared with the same species obtained out of the Middle Lias of Yorkshire, Dorsetshire, and Gloucestershire; and this comparative study led me to determine the series to belong to the zone *Aegoceras Jamesoni*. This collection formed the subject of the notes appended to Professor Geikie's paper communicated to the Geological Society,[2] and of which the following is a *résumé* revised:

Lias Fossils from Pabba, Scalpa, and Skye, Hebrides.

Cephalopoda.

Aegoceras armatum, *Sow.*
— Jamesoni, *Sow.*
— Milleri, *Wright*, n. sp.
— polymorphum, *Quenst.*
— brevispina, *Sow.*
— Davœi, *Sow.*
Arietites tardecrescens, *von Hauer.*
Belemnites elongatus, *Sow.*
— paxillosus, *Schloth.*
— elegans, *Simp.*
— breviformis, *Voltz.*
— clavatus, *Blainv.*

Gasteropoda.

Chemnitzia Blainvillei, *Münst.*
Cerithium Slatteri, *Tate.*
Tectaria imbricata, *Sow.*
Trochus limbatus, *Schloth.*

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[1] Geikie, 'Quart. Journ. Geol. Soc.,' vol. xiv, p. 5, 1858.

[2] Wright, "Notes on the Fossils collected by Mr. Geikie from the Lias of the Isles of Pabba, Scalpa, and Skye," 'Quart. Journ.,' vol. xiv, p. 24, 1858.

Lamellibranchiata.

Pholadomya decorata, *Hartm.*
— ambigua, *Sow.*
Pleuromya ovata, *Römer.*
— Scotica, *Wright.*
Unicardium Ianthe, *d'Orb.*
Pinna folium, *Young & Bird.*
Mytilus scalprum, *Sow.*
— numismalis, *Oppel.*
Leda Zieteni, *Brauns.*
— Galathea, *d'Orb.*
Cardinia attenuata, *Stutch.*
Avicula novemcostæ, *Brown.*
Lima Hermanni, *Ziet.*
— eucharis, *d'Orb.*
Limea acuticosta, *Goldf.*
Inoceramus ventricosus, *Sow.*
Pecten æquivalvis, *Sow.*
— liasinus, *Nyst.*
Plicatula spinosa, *Sow.*
Gervillia Maccullochii, *Wright.*
Gryphæa cymbium, *Lamk.*
— obliquata, *Sow.*
Hippopodium ponderosum, *Sow.*
Astarte striatosulcata, *Römer.*
Arcomya vetusta, *Phill.*
Cucullæa Münsteri, *Goldf.*
Cardita multicosta, *Phill.*
Plicatula spinosa, *Sow.*

Brachiopoda.

Rhynchonella tetraëdra, *Sow.*
— furcillata, *Theod.*
— variabilis, *Schloth.*
Waldheimia numismalis, *Schloth.*
Spiriferina oxyptera, *Buvig.*
— verrucosa, *Buck.*

Crustacea.

Pseudoglyphæa, *sp.*
Glyphæa, sp.

Annelida.

Ditrypa circinata, *Tate.*
Ditrypa quinquesulcata, *Münst.*

Echinodermata.

Pentacrinus robustus, *Wright.*
Pentacrinus lævis, *Miller.*

Foreign Correlations.—In North Germany the *Jamesoni*-beds form the base of the Middle Lias, and are, in part, the equivalent of the Numismalis-marl of Swabia. According to the late Dr. U. Schlönbach, who made a special study of these beds, and recorded the results in an exhaustive memoir,[1] the ironstones of the Middle Lias worked near Harzburg, Liebenburg, Bodenstein, Kalefeld, and Markoldendorf, &c., are obtained from this zone. *Aegoceras armatum* lies in the lowest stratum, *Aeg. Jamesoni* and its other associated Mollusca in higher strata, and the upper portion of the marls passes into beds containing *Aeg. Loscombi, Aeg. Valdani, Aeg. fimbriatum*, and *Amaltheus Ibex*, so that the "Schichten des Ammonites Jamesoni" of Brauns include beds which form the whole of the *Ibex*-beds and part of the *Henleyi*-beds of this work. Last year I obtained from Hechingen three beautiful specimens of *Aeg. Jamesoni*, almost exact replicas of the type of this Ammonite which I had from its original locality, the island of Pabba, and, associated with it, from like beds, *Aeg. Valdani* from the ferruginous marls. Emerson[2]

[1] "Ueber den Eisenstein des mittleren Lias im N.-W. Deutschland," p. 503, 1863; 'Zeitschr. d. deutschen geol. Gesellschaft,' Jahrg. 1863.

[2] 'Die Liasmulde von Markoldendorf,' p. 27, 1870.

gives the following section in the lower half of the Middle Lias, "*in dem 'Klef' und am Abhange des Berges*," in descending order: 1st, *Aeg.-Centaurus*-beds; 2nd, *Aeg.-brevispina*-beds; 3rd, *Aeg.-armatum*-beds. In the first are found *Lytoceras fimbriatum* and *Aegoceras striatum*, in the second *Aeg. Jamesoni* and *Aeg. brevispina*, and in the third *Aeg. armatum* and *Terebratula subovoides* = *T. punctata*.

In South-west Germany, at the foot of the Swabian Alps, the marls of the Middle Lias are seen resting upon Lower Lias clays containing *Arietites raricostatus*. In these, the Numismalis-marls of Quenstedt, are found *Gryphæa obliqua* and *Belemnites elongatus*, which now appear for the first time, *Belemnites acutus*, so common in the older beds, being absent. *Pecten priscus*, *Lima Hermanni*, and other bivalved shells, as *Pholadomya decorata*, are likewise found with *Rhynchonella tetraëdra*, *Rhyn. calcicosta*, and *Spiriferina Münsteri*. Above these forerunners of the new Fauna are large Ammonites, embedded in a calcareous matrix, representing varieties of *Aegoceras armatum*; and in marls still higher in the sections *Aegoceras Jamesoni* appears for the first time associated with *Aegoceras brevispina*, *Aegoceras Taylori*, *Harpoceras Masseanum*, and *Harpoceras arietiforme*. Associated with the Cephalopods are Brachiopods, represented by *Waldheimia numismalis*, *Rhynchonella rimosa*, *Rhynchonella variabilis*, also *Pentacrinus basaltiformis*, with many Mollusca, which represent the zone of *Aegoceras Jamesoni* in Württemberg. It is important to note the very great change that takes place in the life of the Molluscan Fauna with the dawn of the Middle Lias, and to observe the great contrast between the palæontology of the *Jamesoni*, *Ibex*, and *Henleyi* zones, when compared with those we have studied in examining the various successive horizons of life in the Lower Lias.

In France the *Jamesoni*-beds are well developed in several Departments. In Normandy they would appear to be included by Prof. Deslongchamps[1] in the "*Calcaires et Marnes à Terebratula numismalis*." Although not described as marking a distinct zone, the *Aeg. Jamesoni* = *Regnardi*, d'Orb., has been collected at Evrecy, Calvados. In the Côte d'Or the Jamesoni-beds are described by M. Collenot,[2] who divides the Middle Lias near Semur into four zones, designating each by a characteristic species of Ammonite, and in descending order he gives the following:

Zone of *Aeg. Henleyi*, Sow.
„ *Aeg. Davœi*, Sow.
„ *Aeg. Venarense*, Opp.
„ *Aeg. Valdani*, d'Orb.

In the *Valdani*-beds *Aegoceras Jamesoni* is found.

[1] Deslongchamps, 'Études Jurassique Inf. de la Normandie,' p. 42, 1864.
[2] 'Description Géologique de l'Auxois,' p. 260, 1873.

In the Department of the Cher, at Saint-Amand this zone is represented by *Aeg. Jamesoni* = *Regnardi*, d'Orb., *Phyll. Loscombi*, Sow., *Aeg. Valdani*, d'Orb., *Aeg. Maugenesti*, d'Orb., *Amal. Ibex*, Quenst., *Aeg. Centaurus*, d'Orb., *Aeg. brevispina*, d'Orb. In the Department of the Aveyron there is a considerable thickness of Middle Lias composed of limestones and marls. The limestones form the base, the "Zone à *Lyt. fimbriatum*," and the marls occupy the upper portion, the "Zone à *Amal. margaritatus*." Specimens of *Aeg. Jamesoni* have been found in the region, so that the fossils of this zone have not been separated from the *fimbriatum*-beds, as in other localities. In the Department of the Rhone M. Dumortier has studied the fossils of the Middle Lias with great care, and has shown that this division of the formation attains a considerable development in the Basin of the Rhone. He observes, "Considered in relation to its fossils the Middle Lias may be regarded as the reign of Belemnites, for in no other division of the Secondary strata do we recognise the remains of these Cephalopods accumulated in such considerable numbers and appertaining to so many species. The Ammonites also furnish always in lower portions of the stage a very remarkable contingent of large species, and all characteristic of special horizons. The Acephala, Gastropods, and Brachiopods also give a considerable number of species." This author divides the Middle Lias of the Basin of the Rhone into two great zones, very unequal otherwise in their thickness.

The lower is much more developed vertically, and comprises an assemblage of marly limestones and marls, having a total thickness often exceeding eighty mètres = 260 feet, and forming the zone of *Belemnites clavatus*. The upper zone is very clearly separated from the lower by its mineralogical composition and by its fossils; and is characterised by the presence of *Pecten æquivalvis*. The limestones which compose it are throughout very hard, of various colours, very badly stratified, and form a thickness which, in the centre of the basin, does not appear to exceed from six to eight mètres = 20 to 26 feet.

Table of the Middle Lias in the Basin of the Rhone.

Upper Lias.

Zone of Pecten æquivalvis.

Petrology.	Thickness.	Fossils.
	Mètres.	
Calcareous "lumachelle," yellowish or reddish	2 to 3	*Limea acuticosta*, Goldfuss.
Heavy limestone, sublamellar, very hard, yellowish-brown, with large, ferruginous, oolitic grains	2 to 5	*Ostrea sportella*, Dumort.

Zone of Belemnites clavatus.

Petrology.	Thickness.	Fossils.
	Mètres.	
Grey-bluish marls, tender, plastic, without interposed calcareous layers	5 to 10	*Tisoa siphonalis*, Marcel de Serres.
A thin layer of bluish "lumachelle," very hard, charged with pyrites, forming very resisting plaquettes		*Lingula Voltzii.*
Greyish-blue marls, without hard beds	60 to 70	*Tisoa siphonalis*, Marcel de Serres.
Marly limestones, alternating with yellowish marls and greyish ferruginous nodules	2 to 3	*Belemnites paxillosus*, Schloth.
Greyish marly limestone, coarse, hard, and earthy, very often coloured blood-red	2 to 3	*Aegoceras armatum*, Sow.
Total thickness	73 to 94 in the two zones.	

Lower Lias.

It was not possible in this region to correlate the beds by the Ammonites as he had done in other Departments of the Rhone basin, so M. Dumortier selected *Pecten æquivalis* and *Belemnites clavatus* as the organic forms that characterise the different horizons into which he has divided his zone of *Belemnites clavatus*.

9. The Zone of Amaltheus Ibex.

Synonyms.—"Upper Marls," pars, De la Beche, "Lias of Lyme Regis," 'Geol. Trans.,' 2nd series, vol. ii, p. 22, 1823. "Ochraceous Lias," Murchison, 'Geol. of Cheltenham,' 2 Ed., p. 42, 1845. "Die Schichten des *Ammonites Ibex*," Oppel, 'Die Juraformation,' p. 122, 1856. "*Ibex*-bed," Wright, 'Quart. Jour. Geol. Soc.,' vol. xiv, p. 25, 1858. "Schicht. des *Ammonites Centaurus*," Emerson, 'Die Liasmulde v. Markoldendorf,' p. 34, 1870. "Die Schichten des *Ammonites Centaurus*," Brauns, 'Untere Jura,' p. 111, 1871.

This zone was originally exposed at Battledown Hill, near Cheltenham, where it was worked for brick-earth: the bed consisted of an unctuous, tenacious, yellowish clay, containing numerous hard ferruginous nodules, many of which enclosed fossil shells. The same stratum was found in Leckhampton, Charlton Kings, and Churchdown to the south, and at Dumbleton, north of Cheltenham; everywhere the nodules yielded many well-preserved Mollusca, and the following list is characteristic of this zone.

Cephalopoda.

Amaltheus Ibex, *Quenst.*
Aegoceras Valdani, *d'Orb.*
— Maugenesti, *d'Orb.*
— Actæon, *d'Orb.*
— Centaurus, *d'Orb.*
Lytoceras fimbriatum, *Sow.*
Phylloceras Loscombi, *Sow.*
Aegoceras striatum, *Reinecke.*
Belemnites clavatus, *Schloth.*
— elongatus, *Miller.*

Gasteropoda.

Trochus imbricatus, *Sow.*
Trochus lævis, *Schloth.*

Lamellibranchiata.

Cardinia attenuata, *Stutch.*
Mytilus scalprum, *Sow.*
Pinna folium, *Young and Bird.*
Pecten priscus, *Schloth.*
Lima pectinoides, *Sow.*
Avicula inæquivalvis, *Sow.*
Macrodon Buckmani, *Rich.*
Arca truncata, *Buck.*
— elongata, *Buck.*
Gryphæa cymbium, *Lamk.*
Inoceramus ventricosus, *Sow.*
Avicula longiaxis, *Buck.*
Gervillia lævis, *von Buch.*
Hippopodium ponderosum, *Sow.*

Brachiopoda.

Spiriferina rostrata, *Lamk.*
Rhynchonella furcillata, *Théod.*
Waldheimia numismalis, *Lamk.*
Rhynchonella rimosa, *Buck.*

The fossils of this zone in other localities are often catalogued with those from the *Jamesoni*-beds, on which they rest, and it is rare that we are able to define so distinctly the limits of the *Ibex*-beds as formerly we were able to do near Cheltenham.

Mr. E. B. Tawney, F.G.S., has made a careful study of the Lias around Radstock, and embodied his observations in an exhaustive memoir[1] on this subject. From this we learn that the *Ibex*-beds were found by him at Munger, near Radstock, associated with the *Jamesoni*-beds; and that near the top of an old quarry, formerly worked for road-material, he collected *Aegoceras Maugenesti*, *Aegoceras Valdani*, *Aegoceras striatum*, and *Lytoceras fimbriatum*. *Aegoceras brevispina*, *Aegoceras Jamesoni*, and *Amaltheus Ibex* seem to occur throughout, and in the same locality Belemnites were abundant, but not easily extracted. *Belemnites paxillosus* and *B. apicicurvatus*, *Littorinæ* and other minute Gastropods were found in fine preservation with *Cryptænia expansa*. Among the bivalve shells *Astarte striato-sulcata*, *Inoceramus ventricosus*, *Pholadomya ambigua*; and of Brachiopods, *Rhynchonella rimosa* and *Rhyn. furcillata*. We have here a very good account of the *Ibex*-beds of Munger, with the distribution of some of the leading fossils therein.

[1] "Notes on the Lias in the Neighbourhood of Radstock," 'Proc. Bristol Naturalists' Soc.,' vol. i, p. 178, 1875.

This zone appears to extend into Northamptonshire, as the specimens of *Amal. Ibex*, and *Aeg. Valdani* in the British Museum, marked from Watford, testify.

In Dorsetshire I have collected at Lyme Regis fragments of the leading fossils of this zone, as, for example, *A. Valdani*, *A. Maugenesti*, in greyish coloured clay beneath a bed with *Aeg. Davœi*, so that the zone of *Amaltheus Ibex* appears to maintain an independent position above the *Jamesoni*-beds in the localities I have cited wherever we are able to ascertain the position of its fossils with sufficient accuracy to determine the limits of the zone.

Foreign Correlations.—In South-West Germany this zone was first separated from the *Jamesoni*-beds by Dr. Oppel,[1] as he found in beds of clay and marl a few feet thick, resting upon the *Jamesoni*-beds, a group of Ammonites that were constantly associated together, namely, *Amal. Ibex*, *Aeg. Maugenesti*, *Aeg. Valdani*, *Aeg. Actæon*, and *Aeg. Centaurus*, whilst in the *Jamesoni*-beds the group of associates consisted of *Aegoceras Jamesoni*, *Aeg. Masseanum*, *Aeg. submuticum*, *Aeg. Taylori*, and *Aeg. pettos*; and a like distribution of species is found in the two zones in Gloucestershire. The *Ibex*-beds are much more easily discovered round Cheltenham than the *Jamesoni*-beds, which are only reached in some deep brick-earth diggings.

In several of the exposures for obtaining ironstone out of the Middle Lias of North Germany some good sections of the *Jamesoni*, *Henleyi*, and *Margaritatus*-zones have been discovered. The following section, made by the late Dr. U. Schlönbach,[2] of a cutting near Oldershausen shows the relation of the *Ibex* and *Jamesoni* zones to each other in that region.

Section near Oldershausen, between Oldenrode and Echte; the beds taken in descending Order.

No.	Petrology.	Thickness.	Organic Remains.
		ft. in.	
1	A dark red-brown ironstone, with very fine oolitic granules, and containing many petrifactions ..... from 4 to	6 0	*Phyll. Loscombi, Aeg. hybridum, Aeg. brevispina, Aeg. Jamesoni, Aeg. Valdani, Aeg. Gumbrechti, Amal. Oppeli, Belemnites clavatus, B. breviformis, B. elongatus, Nautilus intermedius, Pholadomya decorata, P. obliquata, P. ambigua, P. Hausmanni, Avicula Sinemuriensis, Gryphæa obliqua, Pentacrinus basaltiformis.*
2	A greenish-brown marly limestone, very crumbly, and containing many petrifactions.....	1 8	*Lyt. fimbriatum, Aeg. Valdani, Phyll. Loscombi, Belemnites elongatus, B. breviformis, B. clavatus, B. umbilicatus, Cryptænia expansa, Spiriferina rostrata.*
3	A hard greyish-yellow limestone, often oolitic	0 10	*Aeg. Capricornus, Belemnites elongatus, B. breviformis, B. clavatus, B. umbilicatus, Millericrinus Hausmanni, Pentacrinus nudus.*

[1] 'Juraformation,' p. 122, 1856.

[2] 'Eisenstein des mittleren Lias im N.-W. Deutschland,' p. 493, 1863.

At Markoldendorf,[1] near Einbeck, in a similar exposure for ironstone, he found the above strata with *Aeg. armatum*, *Aeg. Centaurus*, *Aeg. brevispina*, *Aeg. Jamesoni*, *Trochus lævis*, *Pholadomya ambigua*, *Inoceramus ventricosus*, *Gryphæa obliqua*, and many Brachiopods.

Dr. Emerson[2] states that the beds with *Aeg. Centaurus* in the Markoldendorf district yield the richest ironstones in the Middle Lias, and that they alone afford that beautiful granular oolitic structure which is absent from most of the other ironstone masses of that region. In some parts the *Centaurus*-beds rest upon the *Brevispina*-beds, and contain a great number of Gasteropods. The following Mollusca were obtained by this author from these ironstones.

Fossils from the Aegoceras Centaurus-beds at Hullersen.

Lytoceras fimbriatum, *Sow.*
Aegoceras striatum, *Rein.*
— Centaurus, *d'Orb.*
Phylloceras Loscombi, *Sow.*
— Herberti, *Opp.*
Nautilus intermedius, *Sow.*
Belemnites elongatus, *Mill.*
— clavatus, *Schloth.*
Trochus lævis, *Schloth.*
— Retbergi, *Schlön.*
— Thetis, *Goldf.*
Pleurotomaria multicincta, *Schlüb.*
— tuberculato-costata, *Münst.*
— granosa, *Schloth.*
— solarium, *Koch.*
Phasianella phasianoides, *d'Orb.*
Cemoria costata, *Emerson.*
— punctata, *Emerson.*
Opis Carusensis, *d'Orb.*
Isocardia cingulata, *Goldf.*
Unicardium Ianthe, *d'Orb.*
Nucula cordata, *Goldf.*
Leda subovalis, *Goldf.*
— Galathea, *d'Orb.*
Inoceramus ventricosus, *Sow.*
Limea acuticosta, *Goldf.*
Pecten velatus, *Goldf.*
Spiriferina rostrata, *Schloth.*
Pentacrinus basaltiformis, *Mill.*
— nudus, *Schlön.*

In Swabia the three zones of the lower half of the Middle Lias—the *Jamesoni*, *Ibex*, and *Davœi* beds—closely resemble each other, and are only distinguished by the characteristic Ammonites they contain, most of their Gastropods and Lamellibranchs having a wider range in the beds than the Cephalopods, a stratigraphical condition which we have seen to prevail in other zones of life. According to Dr. Oppel[3] the following section fairly represents the actual state of the lower half of the Middle Lias of Swabia.

[1] 'Eisenstein des mittleren Lias im N.-W. Deutschland,' p. 496, 1863.
[2] 'Die Liasmulde v. Markoldendorf bei Einbeck,' p. 34, 1870.
[3] 'Die Juraformation,' p. 123, 1856.

MIDDLE LIAS OF SWABIA.

Upper part of Middle Lias. *Amaltheus margaritatus* begins.

	PETROLOGY.	THICKNESS.	ORGANIC REMAINS.
HENLEYI beds	Hard marly beds, alternating with bluish clay; shells calcareous	ft. 10	*Belemnites umbilicatus* begins here; *Aeg. Davœi, Aeg. Henleyi, Lyt. fimbriatum; Aeg. striatum; Inoceramus ventricosus, Pentacrinus subangularis.*
IBEX beds	Light grey, hard, marly beds, with alternate layers of clay; organic remains pyritic	15–18	*Amal. Ibex, Aeg. Maugenesti, Aeg. Valdani, Aeg. Centaurus, Aeg. Actæon, Waldheimia numismalis, Rhyn. rimosa.*
JAMESONI beds			*Aeg. Jamesoni, Aeg. Masseanum, Aeg. Taylori, Aeg. pettos, Amal. Lynx, Pentacrinus basaltiformis.*
ARMATUM bed	Grey marls	2	*Aegoceras armatum.*

So that the stratigraphical character of the lower half of the Swabian Middle Lias very much resembles the section I have given of the same beds in North Germany at p. 31 of this work, where the classification of Professor von Seebach, Dr. Schlönbach, and Dr. Emerson are arranged for comparison in parallel columns.

In France this zone has been found in Normandy. Professor E. Deslongchamps[1] has described the "*Niveau des Ammonites Valdani et des grosses A. fimbriatus*," which is always well characterised at Bully, Maltot, Fresnay-le-Puceux, and in the environs of Caen, where the *Ammonites Valdani* strata have a thickness of 3 mètres = 10 feet. They consist of granular limestones, sometimes sonorous and siliceous, which cleave sometimes into plates, and enclose a great number of fossils. Large and magnificent specimens of *Lytoceras fimbriatum*, *Amaltheus Engelhardti*, *Amaltheus Ibex*, and *Aegoceras Taylori*, are here found. The most abundant, and most characteristic Cephalopod of this small horizon is the *Ammonites Valdani*, of which the rock, especially at Maltot, sometimes consists. Among the Gastropods are *Trochus, Chemnitzia, Pleurotomaria suturalis*, and *P. similis*, with a large number of Lamellibranchs,—*Panopæa elongata, Pholadomya Hausmanni, Lyonsia unioides, Inoceramus ventricosus, I. substriatus, Hinnites velatus, Pecten orbicularis, P. æquivalvis, Harpax Parkinsoni*. Certain Brachiopods are very characteristic of this zone; in the first line are varieties with a ventral groove, as *Terebratula subovoides, Spiriferina*

[1] 'Études sur les Étages Jurassiques Inférieurs de la Normandie,' p. 48, 1864.

Hartmanni, *S. oxyptera*, and *Rhynchonella furcillata*. Other species are found which pass up into higher beds, such as *Terebratula cornuta*, *T. Waterhousei*, *T. subnumismalis*, *Spiriferina rostrata*, *Rhynchonella tetraëdra*, and *Waldheimia numismalis* rarely.

In the Department of the Cher the late Professor Alcide d'Orbigny[1] well defined the presence of this zone in giving the localities of *Am. Boblayei* = *Ibex*, *Aeg. Maugenesti*, and *Aeg. Valdani*. These Cephalopods, so characteristic of the stage, were collected from the Middle Lias at Coutards, and in the valley of Saint-Pierre, near Saint-Amand, Cher; by MM. Boblaye, Valdan, Maugenest, and d'Orbigny, in beds a little above those descending order, with *Gryphæa arcuata*.

In the Department of Côte-d'Or the lower portion of the Middle Lias is divided by M. Collenot[2] into four zones, each designated by a characteristic Ammonite, in descending order as follow:

1. Zone of Aegoceras Henleyi, *Sow.*
2. Zone of — Davœi, *d'Orb.*
3. Zone of — Venarense, *Opp.*
4. Zone of — Valdani, *d'Orb.*

The "zone of *Am. Valdani*" is locally known as "Calcaire à ciment de Venarey," where it is extensively worked for hydraulic lime, and from whence many fossils are obtained. It was at Venarey, near Semur, Côte-d'Or, and in the environs of Avallon and Yonne, that M. d'Orbigny obtained the type specimens of *Aeg. Valdani*. I found several other species of Cephalopods in the Museum at Semur, which had been obtained from the Calcaire à ciment, but they were found in higher beds than those which had yielded *Aeg. Valdani*, *Aeg. brevispina*, *Aeg. Venarense*, *Phyll. Loscombi*, *Amaltheus Boblayei*, and *Amal. Alisiensis*, all of which appear, from the character of their matrix, to have been derived from the *Valdani*-zone. The leading Ammonite of this zone, *Aegoceras Henleyi*, has been mistaken by d'Orbigny for *Aeg. planicosta*, Sow., from the *Obtusus*-beds of the Lower Lias, and figured as such in the 'Paléontologie Française,' pl. 65. The localities therein given for this Ammonite are important, and prove that this stage of the Middle Lias exists in many other Departments, as Calvados, Meurthe, Moselle, Cher, Ain, Ardennes, Meuse. M. Dumortier,[3] who has corrected the former error as to the identity of *A. Capricornus*, Schloth., says, "*L'Ammonites Capricornus* est avec *l'Amm. Davœi* l'espèce la plus caractéristique et la plus répandue dans les couches inférieures de la zone à *Bel. clavatus;* on la rencontre partout ou ces couches sont abordables." Saint-Fortunat, Rhône, is one of his type localities for this and its other Ammonite associates.

[1] 'Paléontologie Française, Terrains Jurassiques,' tom. i, p. 253, 255, 257, 1842.

[2] 'Description Géologique de l' Auxois,' p. 260, 1873.

[3] 'Études Paléontologiques,' tom. 3, p. 82, 1869.

10. The Zone of Aegoceras Henleyi.

Synonyms.—"Upper Marls" (pars med.), De la Beche, 'Geol. Trans.,' 2nd ser., vol ii, p. 23, pl. iii, 1823. "Der mittlere schwarze Jura," Quenstedt, pars, 'Flötzgebirge Württ.,' p. 172, 1843. "Die Schichten des *Amm. Davœi*," Oppel, 'Juraformation,' p. 126, 1856. "Schiste d'Ethe," Dewalque, 'Lias de Luxembourg,' p. 55, 1857. "Lias Gamma" (pars Davœikalk), Quenstedt, "Der Jura Uebersichstafel," p. 293, 1858. "*Davœi*-bed," Wright, 'Quart. Journ. Geol. Soc.,' vol. xiv, p. 25, 1858. "Zone of *Am. Capricornus*," Wright, 'Oolitic Asteroidea,' Pal. Soc., vol. for 1861, p. 79, 1863. "Zone de la *Belemnites clavatus*," pars Dumortier, 'Études Paléontologiques sur les Dépôts Jurassiques du Bassin du Rhône,' 3me partie, Lias Moyen, p. 16, 1869. "Die Schichten des *Ammonites Davœi*," Brauns, 'Der untere Jura,' p. 124, 1871. "Zone of *Ammonites Capricornus*" Tate and Blake, 'Yorkshire Lias,' p. 89, 1876.

This zone is very well developed in England; and wherever the Middle Lias is complete it is found beneath the rock-bed forming the "Marlstone" of British Geologists. The beds consist of laminated clays, sometimes containing micaceous particles, or they are largely charged with ferric oxide, whilst in other localities the zone is represented by irregular beds of brown micaceous sandstone. The inconstant stony bands found in the clay contain sometimes an assemblage of fossils, and in a few of the beds several interesting forms of *Asteriadæ* and *Ophiuridæ* have been found. At Mickelton,[1] Worcestershire, where the shales of this zone were perforated for a railway tunnel, a considerable number of fossils in fine preservation were obtained; the shales, partly arenaceous and partly micaceous, formed thin slabs of fine bluish sandstone, on which many of the Pentacrinites, Brittle-stars, and Starfishes, lay in high relief. There were also large slabs of ironstone, many inches in thickness, composed almost entirely of shells, with many immature specimens of *Aegoceras Henleyi*. All the specimens of *Uraster Gaveyi*, Forb., *Tropidaster pectinatus*, Forb., *Ophioderma Gaveyi*, with *Cidaris Edwardsii*, Wrt., and *Pentacrinus robustus*, Wrt., were found adherent to the under side of a thick slab of ironstone which lay twenty feet below the surface. The *Cidaris*, and its spines attached to the tubercles of the plates and the ossicles, and species of *Uraster*, *Tropidaster*, and *Ophioderma* were as well preserved for anatomical description as if they had been prepared by a taxidermatist for the purpose.

Beds of laminated shales and ferruginous clays, the equivalent in age of those at Mickelton, were exposed in making excavations at Hewlett's Hill for the reservoirs of the Cheltenham water-works; many of the ironstone bands were full of fossils in various stages of decay, from the decomposition of the calcareous matter of the shell. Another exposure on the same contour line was made at Witcombe, and several of the Ammonites

[1] "On the Railway Cuttings at Mickelton Tunnel, &c.," by G. E. Gavey, F.G.S., 'Quart. Journ. Geol. Soc.,' vol. ix, p. 29, 1853.

and Nautili from that locality, now in my collection, were obtained in fine preservation; the Witcombe shells rivalling those from Mickelton; but no Echinoderms were found with the Mollusca. The following list represents the leading species collected from these beds.

Fossils collected from the Zone of Aegoceras Henleyi, Gloucestershire.

Cephalopoda.

Belemnites umbilicatus, *Blainv.*
— elongatus, *Mill.*
— paxillosus, *Schloth.*
Nautilus striatus, *Sow.*
Aegoceras Henleyi, *Sow.*
— striatum, *Reinecke.*
— Davœi, *Sow.*
Lytoceras fimbriatum, *Sow.*

Gasteropoda.

Chemnitzia capricorni, *Wrt.*
Cylindrites capricorni, *Wrt.*
Trochus imbricatus, *Sow.*
Pleurotomaria similis, *Sow.*
Cryptænia expansa, *Sow.*
— undosa, *Schlüb.*

Lamellibranchiata.

Pholadomya ambigua, *Sow.*
— decorata, *Hartm.*
Pleuromya unioides, *Röm.*
Leda rostralis, *Lamk.*
— complanata, *Röm.*
— acuminata, *Goldf.*
— cordata, *Goldf.*
— inflexa, *Röm.*
Astarte capricorni, *Wrt.*
Mytilus hippocampus, *Young & Bird.*
Cypricardia cucullata, *Goldf.*
Cardinia attenuata, *Stutch.*
Goniomya capricorni, *Wrt.*
Protocardia truncata, *Phil.*
Unicardium Ianthe, *d'Orb.*
Cucullæa Münsteri, *Ziet.*
Arca elongata, *Quenst.*
— truncata, *Buck.*
Modiola scalprum, *Sow.*
Limea acuticosta, *Goldf.*
Avicula longiaxis, *Buck.*
Monotis inæquivalvis, *Sow.*
Inoceramus ventricosus, *Sow.*
— substriatus, *Goldf.*
Pecten æquivalvis, *Sow.*
— priscus, *Schloth.*
— diversus, *Buck.*
— liasinus, *Nyst.*
Gervillia lævis, *Buck.*
Plicatula spinosa, *Sow.*
Gryphæa cymbium, *Lamk.*
Ostrea Goldfussi, *Bronn.*

Brachiopoda.

Terebratula punctata, *Sow.*
Spiriferina rostrata, *Schloth.*
Rhynchonella rimosa, *von Buch.*
Rhynchonella variabilis, *Schloth.*
Orbicula scaliformis, *Wrt.*
Lingula Beanii, *Phil.*

ECHINODERMATA.

Cidaris Edwardsii, *Wright.*
Rabdocidaris Moraldina, *Cott.*
Hemipedina Jardinii, *Wright.*
Uraster Gaveyi, *Forb.*
Tropidaster pectinatus, *Forb.*
Ophioderma Gaveyi, *Wrt.*
— Brodiei, *Wrt.*
Pentacrinus robustus, *Wrt.*
— punctiferus, *Quenst.*
— subangularis, *Mill.*

In Dorsetshire this zone occupies a conspicuous position in the cliff sections, as at Black Ven, Stonebarrow Hill, Westhay Cliff, and at the Golden Cap, all of which exhibit profiles of the beds. Mr. E. C. H. Day, F.G.S.,[1] has given an exhaustive description of these in his excellent memoir; and, as I had the pleasure of working over some of the sections with my friend, I select that at the Golden Cap as the most typical for a general view of the whole. The lower portion of this headland consists of—

I. The Upper Marls, without mica, of De la Beche's section, in which a greater number of Belemnites are found than in any other division of the Lias; seams of grey marls full of these fossils are seen along the shore at low tide. *Belemnites longissimus*, Mill., *B. elongatus*, Mill., and *B. clavatus*, Schloth., appear to be the prevailing forms. Here, likewise, are found *Lytoceras fimbriatum*, *Aeg. Bechei*, *Aeg. Henleyi*, *Aeg. striatum*, *Phylloceras Loscombi*, *Nautilus semistriatus*, d'Orb., *Nautilus inornatus*, *Trochus imbricatus*, *Eucyclus Gaudryanus*, *Chemnitzia Periniana*, *Pleurotomaria similis*, *Cryptænia expansa*, *Inoceramus ventricosus*, *Hinnites tumidus*, *Plicatula spinosa*, *Pecten sp.*

II. The next strata in ascending order are known to local collectors as the "Green Ammonite-beds," as they afford a rich harvest of fossils, which are well preserved in the greenish non-micaceous marls that constitute this stage. It was in these I found the specimens of *Aegoceras Henleyi*, which have enabled me to demonstrate the remarkable history of this species, so long misunderstood by palæontologists, and *Aegoceras Davœi*, the rarest Cephalopod in the locality, associated with *Aeg. Bechei* and *Monotis inæquivalvis* in the same small slab.

Fossils of the Green Ammonite-beds, near Charmouth.

Ichthyosaurus.
Plesiosaurus.
Aegoceras Henleyi, *Sow.*
— Bechei, *Sow.*
— striatum, *Reinecke.*
— Davœi, *Sow.*
Lytoceras fimbriatum, *Sow.*
Phylloceras Loscombi, *Sow.*
Nautilus semistriatus, *d'Orb.*
Belemnites longissimus, *Mill.*
— compressus, *Stahl.*
Cryptænia expansa, *Sow.*
Chemnitzia Carucensis, *d'Orb.*
Pterocera liasina, *d'Orb.*
Inoceramus ventricosus, *Sow.*
Monotis inæquivalvis, *Sow.*

[1] "The Middle and Upper Lias of the Dorsetshire Coast," 'Quart. Journ. Geol. Soc.,' vol. xix, p. 278, 1863.

[2] Ibid., p. 283.

III. Grey marls with the green Ammonite nodules are estimated at one hundred feet in thickness, and are overlain by what is locally called "The Three Tiers," consisting of three beds of hard micaceous sandstone, interstratified with sandy micaceous shale and greyish marls. These beds contain few fossils. The bones of Saurians are sometimes found in the rock beds, together with impressions of *Phylloceras Loscombi* and *Lytoceras fimbriatum*. Over "The Three Tiers" are about 160 feet of grey micaceous marls. Two or three thin bands of mudstone and occasional nodules occur in the lower part of the mass, and at rather more than 100 feet above "The Three Tiers" a thicker band, containing shells and calcareous concretions, stands out from the face of the cliff. Underneath this thick band is a curious and persistent layer of small nodules containing chiefly fragments of Ammonites.

The mass of grey marls terminates with a layer made up of shells and fragments of *Pentacrinites*, and this is immediately overlain by a bed of large sandstones, from 4 to 6 feet in thickness, belonging to the zone of *Amaltheus margaritatus*.

Robin Hood's Bay.—The north cheek of this bay presents a fine exposure of the *Henleyi*-beds, consisting of hard marly shales interstratified with oyster-bands, forming strong rock beds, having a thickness of 60 feet, with blue sandy shales, becoming more argillaceous towards the base with fossiliferous nodules containing *Aeg. Henleyi* and *Lytoceras fimbriatum*. Messrs. Tate and Blake[1] have carefully measured these beds and drawn up the following section:

HENLEYI-*beds, North Cheek, Robin Hood's Bay.*

Base of the Margaritatus-beds.

No.	PETROLOGY.	THICKNESS.	ORGANIC REMAINS.
		ft. in.	
1	Series of thin oyster bands with ripple-marked sandstone between	4 5	*Gryphæa cymbium*, var. *depressa*.
2	Hard speckled shales	4 8	
3	White hardened band, conspicuous at Castle Chamber	0 6	
4	Brown speckly shales	8 6	Wood.
5	Sandy laminated rock oysters, at base 10—12 in.	0 10	*Gryphæa cymbium*, var. *depressa*.
6	Brown speckly shales	1 4	
7	Line of ironstone doggers	0 4	*Aeg. Henleyi*.
8	Brown speckly shales	7 4	*Aeg. Henleyi*.
9	Sandy variable bands, occasional patches of oysters	0 10	
10	Brown speckly shales with large doggers irregularly scattered	3 6	*Gryphæa cymbium*, var. *depressa*.
11	Thin laminated shale	1 8	

[1] 'The Yorkshire Lias,' p. 91.

No.	Petrology.	Thickness.	Organic Remains.
		ft. in.	
12	Oyster bed (the lowest)	0 5	*Gryphæa cymbium*, var. *depressa*.
13	Hard, whitish, slippery shales, irregular doggers.....	4 9	*Aeg. Henleyi, Pholadomya Beyrichii.*
14	Similar shales, irregular doggers	4 6	
15	Similar shales, irregular bands of doggers.....	5 0	
16	Similar shales	11 0	*Aeg. Henleyi.*
17	Small round nodules	0 2	
18	Darker shales, still hard	2 10	
19	Strong ironstone dogger	0 8	
20	Bluish, hard, sandy shale.....	15 6	
21	Ironstone dogger, 6—8 in.	0 6	
22	Similar shale	8 4	
23	Ironstone dogger	4 6	*Aeg. Henleyi, Modiola scalprum.*
24	Similar shale	5 0	
25	Thin lenticular dogger	0 3	*Monotis inæquivalvis.*
26	Similar shale	4 5	*Aeg. Henleyi, Inoceramus ventricosus, Modiola numismalis.*
27	Ironstone dogger, 5—10 in.	0 5	*Aeg. Henleyi.*
28	Whitish crumbly shale	5 0	
29	Dogger	0 6	
30	Shale and irregular dogger	11 0	*Lytoceras fimbriatum.*
31	Shale.....	4 0	*Lytoceras fimbriatum.*
32	Brown shale, hard band of	0 3	
33	Shale.....	5 3	
		128. 2	
	The base of the *Henleyi*-beds.		

Foreign Correlations.—The *Henleyi* = *Capricornus*-beds are found in different regions of North Germany, where they have been discovered in cuttings for railroads and in mining for ironstone, which appears to abound in the lower portion of the Middle Lias of that country; in proof, I may state that *Ammonites Capricornus* has been found in forty different localities in North Germany.

In Brunswick this zone has been described by H. von Strombeck;[1] in the province of Saxony, by Ewald;[2] near Göttingen, by Bornemann;[3] at Harzburg, Oldershausen, Markoldendorf, and in other ironstone districts, by Dr. U. Schlönbach;[4] and from these and other localities Dr. Brauns[5] has been able to make out the following list of species forming the Molluscan Fauna of the *Davœi*-beds = *Henleyi*-beds of North Germany.

[1] 'Zeitschrift der Deutschen geol. Gesellsch.,' vol. iv., p. 65, 1852; 'Sitzungber. der Berliner Akademie,' 1859, p. 354.

[2] 'Über die Jurassischen Bildungen der Provinz Sachsen;' 'Verh. d. Rön Akad. d. Wissench. Berlin,' p. 347, 1859.

[3] 'Liasformation in der Umgegend von Göttingen,' p. 23, 1854.

[4] 'Den Eisenstein des mittleren Lias im N.-W. Deutschland,' p. 487—496, 1863.

[5] 'Der untere Jura im N.-W. Deutschland,' p. 133, 1871.

Palæontology of the Davœi-beds of North-West Germany.

Cephalapoda.

Aegoceras striatum, *Reinecke.*
— Henleyi, *Sow.*
— Davœi, *Sow.*
Lytoceras fimbriatum, *Sow.*
Phylloceras Loscombi, *Sow.*
Amaltheus margaritatus, *Mont.*
Amaltheus Normanianus, *d'Orb.*
Nautilus intermedius, *Sow.*
Belemnites umbilicatus, *Blainv.*
— compressus, *Stahl.*
— clavatus, *Schloth.*
— paxillosus, *Schloth.*

Gasteropoda.

Actæonina variabilis, *Brauns.*
Cryptænia expansa, *Sow.*
— helicinoïdes, *Röm.*
Pleurotomaria similis, *Sow.*
— granosa, *Schloth.*
Discohelix calculiformis, *Dunkr.*
Trochus lævis, *Schloth.*
— turriformis, *Koch and Dunk.*
Trochus limbatus, *Schloth.*
— imbricatus, *Sow.*
— umbilicatus, *Koch and Dunk.*
Rotella turbilina, *Schloth.*
Turbo paludinæformis, *Schlüb.*
— Nicias, *d'Orbig.*
— marginatus, *Ziet.*
Turritella undulata, *Ziet.*

Lamellibranchiata.

Gryphæa cymbium, *Lamk.*
Ostrea semiplicata, *Münst.*
Anomia numismalis, *Quenst.*
Plicatula spinosa, *Sow.*
Hinnites tumidus *Ziet.*
Pecten priscus, *Schloth.*
— æquivalvis, *Sow.*
— substriatus, *Röm.*
— lunularis, *Röm.*
Lima Hermanni, *Ziet.*
Limea acuticosta, *Goldf.*
Leda complanata, *Goldf.*
— Galathea, *d'Orb.*
— subovalis, *Goldf.*
Nucula cordata, *Goldf.*
Cucullæa Münsteri, *Ziet.*
Macrodon Buckmani, *Rich.*
Inoceramus ventricosus, *Sow.*
Avicula inæquivalvis, *Sow.*
— calva, *Schlub.*
— cygnipes, *Young and Bird.*
Pinna folium, *Young and Bird.*
Modiola elongata, *Koch and Dunk.*
Astarte striatosulcata, *Röm.*
Myoconcha decorata, *Munst.*
Cardium cingulatum, *Goldf.*
Protocardia truncata, *Sow.*
Thracia Grotriani, *Brauns.*
Pholadomya decorata, *Ziet.*

Brachiopoda.

Rhynchonella variabilis, *Schloth.*
— tetraëdra, *Sow.*
— rimosa, *Buch.*
— furcillata, *Théod.*
Spiriferina rostrata, *Schloth.*
Waldheimia numismalis, *Lamk.*
Waldheimia cornuta, *Sow.*
— Waterhousei, *Dav.*
— Heyseana, *Dunk.*
— punctata, *Sow.*
— subovoides, *Röm.*
Terebratella subpentagona, *Koch and Dunk.*

ECHINODERMATA.

Cidaris octoceps, *Quenst.*
— sp. (from Göttingen).
Pentacrinus subangularis, *Mill.*
Pentacrinus basaltiformis, *Mill.*
Millericrinus Hausmanni, *Röm.*

FORAMINIFERA.

Glandulina vulgata, *Born.*,
and nine other species.
Nodosaria novemcostata, *Born.*
Orthocerina multicostata, *Born.*
— pupoides, *Born.*
Frondicularia bizæformis, *Born.*,
and four other species.
Lingulina tenera, *Born.*
Vaginulina Hansmanni, *Born.*
Marginulina rugosa, *Born.*
Cristellaria protracta, *Born.*,
and nine other species.
Robulina Gottingensis, *Born.*
— nautiloides, *Born.*

All the above thirty-three species of Foraminifera were obtained from the Belemnite-beds of Göttingen, and figured and described by Dr. Bornemann, in his memoir, "Ueber die Liasformation in der Umgegend von Göttingen."

11. The Zone of Amaltheus margaritatus.

Synonyms.—"Blue Lias Marl," pars sup., William Smith, 'Mem. of Map.,' 1815. "Micaceous Marl," De la Beche, 'Geol. Trans.,' 2nd series, vol. ii, pl. 3, 1823. "Marlstone," Williamson, "Fossil Remains on the Yorkshire Coast," 'Geol. Trans.,' 2nd ser., vol. v, p. 224, 1836. "Lias Delta, Amaltheenthon," Quenstedt, 'Flözgeb.,' p. 540, 1843. "The Marlstone," Murchison, 'Geol. of Cheltenham,' 2nd edit., p. 37, 1845. "Marnes à *Ammonites amaltheus* ou *margaritatus*," Marcou, 'Jura Salinois,' p. 50, 1846. "Amaltheenschichten," v. Strombeck, 'Zeitschrift d. Deutsch. Gesell.,' p. 88, vol. v, 1853. "Macigno d'Aubange," Dumont, Dewalque et Chapuis, 'Luxembourg,' p. 273, 1853. "Die oberen Schichten des *Ammonites margaritatus*," Oppel, 'Jura-formation,' p. 133, 1856. "Marlstone," Hull, 'Memoirs of the Geol. Survey,' descrip. of sheet 44, p. 18, 1857. "Oberer Theil des mittleren Lias," Ewald, 'Sitzung. Berlin Akad, 1859. "Margaritatus-bed," Wright, 'Quart. Journ. Geol. Soc.' vol. xv, p. 25, 1860. "Obere Zone des *Am. margaritatus*, Zone des *Am. spinatus*," U. Schlönbach, 'Eisenstein des mittleren Lias,' p. 507, 1863. "Amaltheenthone," von Seebach, 'Hannoversche Jura,' p. 25, 1864. "Lias Moyen, Partie Supér., Zone of *Pecten æquivalvis*," Dumortier, 'Étude Pal.,' vol. iii, p. 206, 1869." Amaltheenthone," Brauns, 'Untere Jura,' p. 141, 1871. "Marlstone and ironstone series," Phillips, 'Geol. of York,' 3rd edit., p. 156, 1875. "The Marlstone of the Middle Lias," Judd, 'Geology of Rutland,' p. 64, in 'Mem. of the Geol. Surv.,' 1875. "Zone of *Am. margaritatus*," Tate and Blake, 'Yorkshire Lias,' p. 103, 1876.

The "Marlstone" of English Geologists forms a marked division of the Middle Lias. In the Midland Counties it consists of a lower portion, composed of yellowish-brown sandy beds, with thin bands of limestone and ferruginous nodules, and of an upper portion or rock-bed, formed of impure limestone containing many fossil shells in good preservation; it weathers brown externally from the oxidation of the iron it contains, whilst it is blue internally when broken with the hammer. This rock-bed forms a solid capping to the lower arenaceous beds, the more rapid erosion of which along their outcrop in Marlstone districts produces those terraces and tabulated promontories, as at Gretton, Alderton, Dumbleton, Churchdown, and Stinchcombe Hills, which impart such a picturesque effect to the physiographic features of the western escarpment of the Cotteswolds; whilst the steep slopes descending from the edges of the platforms to the Lower Lias plain below are composed of softer beds of Liassic sands and clay that have undergone a greater amount of atmospheric erosion.

North of Cheltenham the Marlstone is exposed in large quarries at Bredon, Alderton, Dumbleton, and Gretton Hills, where it was formerly worked for road-material. From Gretton I collected a large number of fossil shells, many of which had their tests in good preservation. In these localities, however, it is difficult to separate the *Margaritatus*-from the *Spinatus*-bed. South of Cheltenham the Marlstone is found at the summit of Churchdown Hill, a remarkable circumdenuded outlier of the Cotteswolds, and on the western slope of Robin's Wood Hill, another outlier of the same; at Frocester Hill it forms a terrace of hard calcareo-siliceous limestone, which rests upon brown and greyish sands, containing bands and nodules of ferruginous ironstone; the whole of the Middle Lias here measuring about 150 feet in thickness, and divisible into *Jamesoni*, *Ibex*, *Henleyi*, and *Margaritatus* beds very similar in their petrological characters to those already described. The fine mass of Stinchcombe Hill, which projects like a bold headland into the valley, exhibits a greater thickness of Marlstone than any other section in the Cotteswolds; the Newent quarry near the village of Stinchcombe has twenty feet of Marlstone, covered by five feet of Upper Lias clay. At Wotton-under-Edge the Middle Lias is 186 feet thick, as measured by my old esteemed friend Professor A. Ramsay, F.R.S., Director-General of the Geological Survey, who many years ago surveyed this district, and was kind enough to draw for me the following profile of this interesting bit of the Cotteswold range.

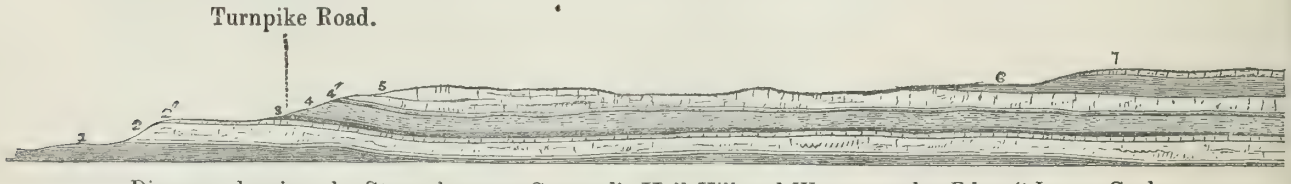


Diagram showing the Strata between Symond's Hall Hill and Wotton-under-Edge ('Journ. Geol. Soc.,' vol. xvi, p. 307.

This section shows the succession of Jurassic strata from Symond's Hall Hill to the Vale of Gloucester, and which, read in ascending order, includes—

1. The Lower Lias shale and limestone of the Valley of the Severn; thickness unknown.

2. The sands, shales, and clays of the Middle Lias; 186 feet in thickness.

2′. The hard, brown, fossiliferous Rock-bed, or Marlstone capping the terrace; 12 feet.

3. The Upper Lias shales in thin beds, with nodules of limestone at the top; 10 feet thick.

4. The Upper Lias sands, containing hard sandy nodules and lenticular concretions in the upper part, and brown, ferruginous, loose sand in the lower portion; 123 feet thick.

4′. Hard, brown, calcareous, sandy bands, freely speckled with granules of ferri-silicate, and interstratified with layers of softer sand containing *Ammonites*, *Belemnites*, *Nautili*, &c., in considerable numbers, and forming a *Cephalopoda*-bed, sixteen feet thick; this is correlative with the one to be described at Frocester Hill.

5. The Inferior Oolite Limestone, similar to the Frocester and Painswick rocks, forming the freestone or building-stone of the district. Eighty feet thick.

6. The Fullers Earth; 128 feet thick.

7. The Great Oolite, forming the summit of Symond's Hall Hill and the plateaux of the Cotteswolds in this region.

At South Petherton in Somersetshire the Marlstone was formerly extensively worked for road-material; the beds are thin but very fossiliferous, and many fine specimens were obtained therefrom. All my finest *Amaltheus margaritatus* and *Amal. Engelhardti*, and several *Lamellibranchiata* and *Brachiopoda*, with their tests in a beautiful state of preservation, came from this locality.

Fossils from the Marlstone or Margaritatus-zone in Gloucestershire.

VERTEBRATA.

Vertebræ of Ichthyosaurus.

Teeth and scales of Fishes.

CEPHALOPODA.

Belemnites clavatus, *Blainv.*
— Milleri, *Phill.*
Nautilus striatus, *Sow.*
— truncatus, *Sow.*
Amaltheus margaritatus, *Montf.*
Amaltheus Englehardti, *d'Orb.*
Harpoceras Normanianum, *d'Orb.*
Phylloceras heterophyllus amalthei, *Quenst.* = zetes, *d'Orb.*

GASTEROPODA.

Pleurotomaria similis, *Sow.*
— undosa, *Deslong.*
— Sabrina, *Tate.*
Cryptænia expansa, *Sow.*
Chemnitzia Blainvillei, *Münst.*
Discohelix aratus, *Tate.*
Eucyclus imbricatus, *Sow.*

LAMELLIBRANCHIATA.

Pholadomya ambigua, *Sow.*
Pleuromya granata, *Simp.*
— concinna, *Goldf.*
— costata, *Young and Bird.*
— ovata, *Röm.*
Cardinia crassissima, *Sow.*
Goniomya capricorni, *Wrt.*
Cucullæa Munsteri, *Ziet.*
Gresslya intermedia, *Simp.*
Cypricardia cucullata, *Münst.*
Modiola scalprum, *Sow.*
Limea acuticosta, *Goldf.*
Monotis inæquivalvis, *Sow.*
Ceromya lineata, *Will*
Arcomya elongata, *Röm.*
Unicardium cardioides, *Phil.*
Protocardium truncatum, *Phil.*
Cardinia crassiuscula, *Sow.*
Lima Hermanni, *Voltz.*
— duplicata, *Sow.*
— pectinoides, *Sow.*
Pecten calvus, *Goldf.*
— æquivalvis, *Sow.*
— lunularis, *Röm.*
Gryphæa cymbium, *Lamk.*
Ostrea margaritacea, *Wrt.*

BRACHIOPODA.

Terebratula punctata, *Sow.*
Waldheimia resupinata, *Sow.*
— cornuta, *Sow.*
— Edwardsii, *David.*
Rhynchonella tetraedra, *Sow.*
— variabilis, *Schloth.*
— acuta, *Sow.*
Lingula Beanii, *Phil.*

ECHINODERMATA.

Cidaris Edwardsii, *Wrt.*
Hemipedina Jardinii, *Wrt.*
Ophioderma Milleri.
Ophiolepis Murravi, *Wright.*
Extracrinus subangularis, *Mill.*
Pentacrinus gracilis, *Charlesworth.*

The Marlstone attains a great development in Yorkshire, and is fully exposed in the coast sections near Staithes, Colborn Nab, and Boulby. "The sandy, conchiferous marlstone beds," says Prof. Phillips,[1] "which in Colborn Nab cover the Lower Lias shale, are seen rising with it and contributing to swell the altitude of Boulby and Rock-cliff. The lower part of this series is generally the most solid, and projects in broad, compact floors above the Lias. On the surfaces of such beds lie innumerable multitudes of Oysters, Dentalia, Pectens, *Protocardium truncatum*, *Monotis inæquivalvis*, and more rarely, about Staithes, beautiful fossil Star-fishes of the genus *Ophioderma*." In Boulby Cliffs[2] the ironstone and Marlstone series consist of—

a. The ironstone bands, which are numerous layers of firmly connected nodules of ironstone, often septariate, and enclosing coniferous wood, Pectines, Aviculæ, Terebratulæ, and from twenty to forty feet thick.

b. The Marlstone series, consisting of alternations of sandy Lias shale and sandstones, which are frequently calcareous, and generally full of shells. The lower beds are usually more solid, and project from the cliffs in broad floors, covered with Pectens, Cardia, Dentalia, Aviculæ, Gryphææ, &c. The thickness variable from forty to 120 feet.

The molluscan fauna of these beds closely resembles the list already given from the Marlstone of Gloucestershire. Among the Echinodermata, however, are found species

[1] 'Geology of Yorkshire,' p. 101. [2] Ibid., p. 102.

which are limited to the Yorkshire series, as *Uraster carinatus*, Wr., *Astropecten Hastingsiæ*, Forb., *Ophioderma Milleri*, Phil., *Aspidura loricata*, Will., and *Ophiura Murravii*, Forb., all collected from the Marlstone series near Staithes, where one of the most instructive sections of the *Margaritatus*-beds is exposed in the cliff. The following section, by Messrs. Tate and Blake,[1] has more detail than mine, so I have selected it.

Section of the Margaritatus*-beds at Staithes.*

No.	Petrology.	Thickness. ft.	Thickness. in.	Organic Remains.
	Zone of Amaltheus spinatus.			
1	Bottom seam of impure ironstone : shells enveloped in a calcareous matrix ...	2		*Amal. margaritatus, Belemnites, Pecten æquivalvis, Gryphæa cymbium, Cypricardia cucullata.*
2	Blue marly shale ; top surface crowded with Belemnites ..... Blue shale	4	3	*Amal. margaritatus, Belemnites, Pecten æquivalvis,* fossil Wood.
3	Fine-grained argillaceous limestone ...	0	1	
4	Blue shale	5	5	
5	Band of clay-ironstone, slightly speckled with white grains ; forms a scar on the flat shore	0	10	*Amal. margaritatus, Protocardium truncatum, Monotis cygnipes.*
6	Black splintering shale	9	8	
7	Oval argillaceous limestone doggers Black splintery shale	5	4	
8	Clay-ironstone in two blocks, weathering brick-red	2	0	*Amal. margaritatus, Gryphæa cymbium, Protocardium truncatum.*
9	Shale.....	1	0	
10	Argillaceous limestone dogger.....	0	8	
11	Shale.....	0	2	*Gryphæa cymbium.*
12	Small doggers	0	1½	
13	Shell-bed	0	1½	Belemnites and oysters.
14	Sandy shale with scattered doggers ...	2	11	*Gresslya Seebachii.*
15	Blue, with doggers and shell masses ...	6	0	*Gresslya Seebachii, Protocard. truncatum, Pecten æquivalvis, Macrodon intermedius.*
16	Shale, with doggers and shell-masses...	10	6	
17	Dogger band	0	4	*Amal. margaritatus, A. Capricornus,* and many other fossils.
18	Marly shale	8	0	
19	Sandy shale and doggers.....	7	0	
20	Calciferous sandstone	0	3	
21	Sandy marls.....	2	9	*Gresslyæ.*
22	Dogger band.....	0	3	
23	Sandy marls	2	0	
24	Blue limestone	1	0	
25	Striped sandy shales, with fossiliferous doggers and their sandstones	17	2	*Amal. margaritatus, Chemnitzia Blainvillei, Protocardium truncatum.*
26	Reddish sandstone with bands of fossils	2	6	*Dentalium giganteum, Protocardium truncatum, Lima Hermanni, Monotis cygnipes,* &c.
27	Grey sandstone and flags, false bedded	6	6	
28	Calciferous sandstones.....	6	2	
29	Soft marly sandstone and calciferous sandstone bands	4	0	

At the base of the cliff, on the south side of the harbour, the following lower beds are exposed at low tide.

[1] 'Yorkshire Lias,' p. 107.

Sandy shales, impure limestone bands, grey marly sandstone, blue micaceous sandstone; about ten feet thick, containing *Protocardium truncatum*, *Pecten æquivalvis*, *Belemnites virgatus*.

My friend Professor Judd, in his able and exhaustive 'Memoir on the Geology of Rutland,' gives the following account of the Marlstone or Middle Lias in that county. "The upper part is a mass of ferruginous limestone, known as the Rock-bed; the lower, a series of sandy and micaceous clays and iron-stone with some beds of sand. The succession of beds in the Marlstone is as follows in ascending order, beginning at the base:

"*a*. Soft, yellowish-brown, sandy, and micaceous ironstone, crowded with casts of shells and alternating with light blue clays. These ferruginous bands vary very greatly in number and thickness, and are sometimes nodular. They are especially characterised by the abundance of several small varieties of *Ammonites margaritatus*, Montf., and *Protocardium truncatum*, Sow.

"*b*. Beds of blue, highly micaceous clay, with large septaria crowded with fossils." Only in two brick-yards. "The most abundant species in these beds are *Ammonites margaritatus*, Mont. (the large typical form), *Belemnites elongatus* Mill., *Cryptænia expansa*, Sow., *Avicula inæquivalvis*, Sow., *Mytilus hippocampus*, Young and Bird, *Modiola scalprum*, Sow. (very abundant), *Protocardium truncatum*, Sow., *Pleuromya unioides*, Röm., and *Pentacrinus subangularis*, Mill.

"*c*. Beds of blue clay, with septaria, the latter not unfrequently containing Specular Iron, and weathering to a red colour. They contain many of the fossils recorded from the preceding beds, but less abundantly. . . . . .

"*d*. Light blue clays, with bands of ironstone balls of concentric structure, and usually very unfossiliferous. These beds are exposed in some brick-yards." At some places they contain beds of green and brown sands, as near Horninghold.

"*e*. 'The Rock-bed.' This is a mass of limestone, more or less ferruginous, and occasionally passing into a good ironstone. When unweathered it is a hard crystalline rock, of a blue or green colour, but as usually seen it is brown and moderately soft. It is usually crowded with fossils, its mass being often made up of fragments of crinoids, spines of Echinoderms, Serpulæ, and fragments of shells, whilst certain beds in it consist of an agglomeration of shells of *Rhynchonella tetrahedra*, Sow., and *Terebratula punctata*, Sow., often filled with finely crystallized calc-spar. *Belemnites paxillosus*, Schloth., and *B. elongatus*, Mill., are extremely abundant in the Marlstone Rock-bed, and serve to distinguish it from the Northampton Sand, which often resembles it in mineralogical characters, but in which *Belemnites* are exceedingly rare. *Ammonites* are not abundant in the Rock-bed in this district, but at some points, as Edmondthorpe, Loddington, and Horninghold, *Ammonites communis*, Sow., and *Am. annulatus*, Sow., occur in considerable numbers; *Am. spinatus*, Brug., and some varieties of *Am. margaritatus*, Montf., are also found in it, but much more rarely, in this district. Large specimens of *Pecten*

[1] "The Geology of Rutland," 'Memoirs of the Geological Survey,' p. 64, 1875.

æquivalvis, Sow., with the highly characteristic *P. dentatus*, Sow., also *P. sublævis*, Phil., *Hinnites abjectus*, Phil., and *Avicula inæquivalvis*, Sow., are among the most abundant forms in the Rock-bed.

"The Marlstone Rock-bed is very variable, both in thickness and mineralogical character; it is finely developed in the neighbourhoods of Tilton-on-the-Hill and Somerby, near the former of which places it is seen to measure 18 feet 6 inches in thickness; towards the east and south, however, it attenuates very rapidly. . . . . Besides being greatly diminished in thickness, the Rock-bed sometimes loses its calcareous character and becomes sandy. . . . . When the junction of the Upper Lias clay and the Marlstone Rock-bed is seen, the latter often presents the appearance of having suffered erosion before the deposition of the former."

I have given my learned friend's description *in extenso*, as it is a very clear and concise account of the Marlstone Rock-bed of the Middle Lias as it exists throughout the midland district of England. The Lias *a*, *b*, *c*, *d*, according to the classification I have followed in this work, would belong to the zone of *Amaltheus margaritatus*, and *e*, the Rock-bed, would fairly represent the zone of *Amaltheus spinatus*. It is noteworthy in passing that both in this section, and in another which I shall give of Down Cliff when describing the *spinatus*-beds in Dorsetshire, we shall find that the Ammonites of the upper Lias, *Stephanoceras commune* and *Steph. annulatum*, are sometimes found side by side with *Amaltheus spinatus*, which dies out in the upper part of this zone.

I must refer the student for ample details about these two zones to Professor Judd's memoir, as it is replete with instructive sections of the *Margaritatus*-beds and their fossils from the different brick-yards examined, and of the *Spinatus*-bed or Marlstone Rock-bed at Robin-a-Tiptoes.

In Warwickshire this zone is very well developed near Banbury, where it has been long and carefully studied by Mr. Beesley, F.C.S., who has given a very good account of the formation.[1] According to this author the *Margaritatus*-beds form the base of the Upper Middle Lias, and consist of blue micaceous marly clay, with nodules of hard marl or claystone; above this are hard bluish calcareous sandstone embedded in sand, and overlain by sandy marl or clay, containing the usual fauna of the *Margaritatus*-beds of Rutland, with many additional species collected through several years by local geologists.

The Marlstone Rock-bed, or *Ammonites spinatus* zone forms the top of the Upper Middle Lias, and is its most characteristic feature, being largely spread over the district, and forming a broad table-land. On the west and south, and a terrace on the east side of the valley, the disintegration of its friable stone has produced the rich red land so well adapted for wheat-growing.[2] The Rock-bed is a ferruginous often sandy limestone, externally brown, but of a greenish-blue colour in the interior of the blocks, and is usually separated by thin partings of sandy loam or clay into two or three beds,

[1] 'Sketch of the Geology of the Neighbourhood of Banbury,' p. 5, 1872.

[2] Ibid., p. 6.

containing flattened concretionary nodules, which are rich in phosphates, the decomposition of which contributes to the fertility of the soil. Silicate of iron in small, rounded, highly polished, often hollow grains, is sometimes so abundant as to give almost an oolitic structure to the rock.

At Adderbury and at King's Sutton extensive workings for ironstone are now carried on in these beds, which are the correlative series in the midland districts of the great ironstone beds of Yorkshire, and are estimated to yield from 18 to 24 per cent. of iron.

Mr. Beesley has collected eighty species of Mollusca from the *Spinatus*-beds; and in this list are included, with *Amaltheus spinatus* and *Amal. margaritatus*, two Ammonites which belong to the Upper Lias. It would appear that here, as in other localities, it is extremely difficult to separate certain forms from each other along the confine lines of these zones, and hence we learn how the *Spinatus*- and *Margaritatus*-beds have been united and considered as one by most British geologists.

The Middle Lias zones above the *Jamesoni*-beds are exposed in the Island of Raasay, along the stream-courses on the Hallaig Moor; and, according to Professor Tate,[1] form a grand section on the east side of the island, displaying a gradual passage from argillaceous sediments into the calcareo-arenaceous rocks which constitute so striking a feature in the lithology of the Middle Lias of this area. A section of 150 feet shows the following beds:

I. *Spinatus*-beds: 1, yellow calciferous sandstone with ferruginous nodules.

II. *Margaritatus*-beds consisting of, 2, fissile sandstone; 3, shelly, ferruginous sandstone; 4, marly sandstone; 5, grey marls; 6, greenish-yellow sandstone, with shaly partings; 7, yellow sandstone; 8, greenish marly sand beds.

III. *Henleyi*-beds: 9, greenish-yellow calcareous sandstone; 10, greenish calcareous sandstone, with indurated tops.

In the cliff section on the east coast of Skye these three zones are repeated with similar petrological conditions; and from the *Henleyi*-beds the following fossils were collected by Messrs. Tate and Bryce, near Portree, Isle of Skye.

Fossils from the Henleyi-zone, Skye.

Aegoceras Henleyi, *Sow.*
— Davœi, *Sow.*
— striatum, *Reinecke.*
Pecten æquivalvis, *Sow.*
— liasinus, *Nyst.*
Avicula novemcostæ, *Brown.*
Limea acuticosta, *Münst.*
Unicardium Janthe, *d'Orb.*
Protocardium truncatum, *Phil.*
Pholadomya ambigua, *Sow.*
— decorata, *Ziet.*
Pleuromya ovata, *Röm.*
Mytilus scalprum, *Sow.*
Arca Stricklandi, *Tate.*
Cypricardia cucullata, *Goldf.*
Inoceramus ventricosus, *Sow.*
Gryphæa cymbium, *Lamk.*
— obliqua, *Sow.*
Hippopodium ponderosum, *Sow.*
Pinna folium, *Young & Bird.*
Cucullæa Münsteri, *Ziet.*
Rhynchonella tetraedra, *Sow.*
— variabilis, *Sow.*

[1] 'Quart. Journ. Geol. Soc.,' p. 343, vol. xxix, 1873.

On the south side of Portree harbour thin-bedded, bluish, micaceous sandstones, forming the *Margaritatus*-beds, are exposed, and yielded the following shells, which were chiefly collected in Raasay:

Fossils from the Margaritatus-zone, Island of Raasay.

Amaltheus margaritatus, *Montf.*
Belemnites paxillosus, *Schloth.*
— breviformis, *Voltz.*
— longissimus, *Mill.*
Tectaria Gaudryana, *d'Orb.*
Chemnitzia Blainvillei, *Münst.*
Pecten æquivalvis, *Sow.*
— liasinus, *Nyst.*
— strionates, *Tate.*
Avicula novemcostæ, *Brown.*
— cygnipes, *Young* and *Bird.*
Lima Hermanni, *Voltz.*
Limea acuticosta, *Münst.*
Pleuromya ovata, *Röm.*
Pholadomya ambigua, *Sow.*
Mytilus scalprum, *Sow.*
Leda graphica, *Tate.*
Ostrea cymbium, *Lamk.*
Plicatula spinosa, *Sow.*
Cypricardia cucullata, *Goldf.*
Macrodon intermedius, *Simp.*
Arcomya arcacea, *Seebach.*
Ceromya liassica, *Tate.*
Lingula Voltzii, *David.*
Rhynchonella acuta, *Sow.*
— subconica, *David.*
— tetraedra, *Sow.*
Terebratula punctata, *Sow.*
Spiriferina Münsteri, *David.*
— rostrata, *Schloth.*
Eryma propinqua, *Blake.*
Pentacrinus amalthei, *Quenst.*

Foreign Correlations.—The *Margaritatus* and *Spinatus* zones are widely distributed in North Germany, and, although these two horizons may sometimes be separated, they often are so closely united that they must be studied together. Von Strömbeck[1] has made careful studies of the Amaltheenschichten in different regions of that country, and found them in the Helmsted, Schöppensted, and Harzburg Jura, containing *Amal. margaritatus, Amal. spinatus, Cryptænia expansa, Turbo cyclostoma, Gresslya ventricosa, Astarte striato-sulcata, Leda elliptica, Inoceramus substriatus.* Ewald[2] found the same species near Halberstadt; H. Römer, near Hildesheim; Bornemann, near Göttingen; Credner,[3] in Hilsmulde, near Stroit; and Schlönbach,[4] near Liebenburg and near Salzgitter, with a similar assemblage of Mollusca; so that the upper zones of the Middle Lias are well represented in the north. In South Germany the *Margaritatus*-beds are found in Swabia, and were long ago described by Professor Quenstedt in his 'Flötzgebirge Württembergs,' and afterwards by Dr. Oppel in 'Der mittlere Lias Schwabens,' whilst in his 'Juraformation' he divided the *Margaritatus*-beds into a lower and upper zone.

In the lower zone *Amal. margaritatus* is often associated with *Lytoceras fimbriatum*

[1] 'Zeitschrift d. D. geol. Gesellschaft,' vol. v, Jahrg., 1853.
[2] Ibid., 1859.
[3] 'Jahrbuch f. Min.,' 1860.
[4] 'Zeitschrift d. D. geol. Gesellschaft,' vol. xv, Jahrg., 1863.

and *Lyt. lineatum*, and in the upper zone *Amal. margaritatus* is associated with *Amal. spinatus*. It would appear that *Amal. magaritatus* has a considerable vertical range, both in Germany and France, and thereby links together the *Henleyi* and *Spinatus* horizons in these countries by a persistent Cephalopodous type. *Amaltheus margaritatus* is thus remarkable alike for its zoological characters, and its wide distribution in time and space.

In France the *Margaritatus*-beds are exposed at Vieux-Pont, Calvados. Professor Deslongchamps[1] has given a section of this, which evidently represents the English Marlstone; it consists of a Rock-bed about five feet in thickness, enclosing a large assemblage of fossils, of which the most characteristic are *Amal. margaritatus, Amal. spinatus, Belemnites niger, Pecten æquivalvis, Pecten disciformis, Lima punctata, Terebratula quadrifida, Ter. cornuta, Ter. punctata, Ter. Edwardsii, Rhynchonella acuta, Rhyn. tetraedra, Spiriferina rostrata.* Its upper portion is characterised by a particular stratum charged with small Gastropods of the genera *Turbo, Cerithium, Tornatella, Actæonina,* and sometimes *Pleurotomaria precatoria.* In the adjoining region, as at Évrecy, Landes, Curcy, and Croisilles, the same bed is found maintaining its lithological and palæontological characters with a remarkable constancy. This zone has an extensive distribution in other Departments of France, and the characteristic Ammonites are found near Nancy, Meurthe; Saint-Rambert, Ain; Venarey, near Semur, and Pouilly in Auxois Côte d'Or; St. Amand, Cher; Metz, Moselle; Avallon, Yonne; near Lyons, Rhône; Clapier and Bosc, Aveyron; where it is associated with a number of new Ammonite forms that appear to be special to the Mediterranean area.

The late Dr. Reynès, of Marseilles, collected, figured, and described these Cephalopods, which were chiefly obtained from the *Margaritatus*-beds at Clapier, Bosc, Rivière, Tournemire; and has given the following remarkable list[2] from this portion of the Department of the Aveyron:

CEPHALOPODA.

Belemnites elongatus, *Mill.*
— niger, *Mill.*
— breviformis, *Voltz.*
Nautilus, sp.
Ammonites spinatus, *Brug.*
— margaritatus, *Montf.*
— mimatensis, *d'Orb.*
— Ægion, *d'Orb.*
— Ragazzonii, *Hauer.*
— acanthoides, *Reynès.*
— pseudoradians, *Rey.*
— Nilssoni, *Hébert.*
Ammonites Algovianus, *Oppel.*
— Alberti, *Rey.*
— Herbeti, *Rey.*
— ruthenensis, *Rey.*
— Partschi, *Stur.*
— Boscensis, *Rey.*
— Loscombi, *Sow.*
— Kurrianus, *Oppel.*
— instabilis, *Rey.*
— Fieldingi, *Rey.*
— plainspira, *Rey.*
— disciformis, *Rey.*

[1] 'Études sur les Étages Jurass. infér. de la Normandie,' p. 51, 1864.

[2] 'Géologie et de Paléontologie Aveyronnaises,' p. 50, 1868.

Ammonites frondosus, *Rey.*
— Coquandi, *Rey.*
— Maresi, *Rey.*
— Woodwardi, *Rey.*
Ammonites Spinelli, *Hauer.*
— lineatus, *Quenst.*
— globosus, *Ziet.*
— Phillipsi, *Hauer.*

Gasteropoda.

Turritella Zieteni, *Quenst.*
Chemnitzia undulata, *Benz.*
Cryptænia expansa, *Sow.*
Pleurotomaria Amalthei, *Quenst.*
Turbo Dunkeri, *Goldf.*
Trochus imbricatus, *Sow.*

Lamellibranchiata.

Pholadomya Heberti, *Rey.*
Nucula Palmæ, *Sow.*
— Bruni, *Rey.*
— complanata, *Phil.*
— variabilis, *Ziet.*
— acuminata, *v. Buch.*
Venus bombax, *Quenst.*
Arca strigillata, *Münst.*
— Sauvairei, *Rey.*
Cucullæa Münsteri, *Goldf.*
Avicula cygnipes, *Phill.*
Cardium cucullatum, *Goldf.*
Plicatula Parkinsoni, *Deslong.*
— pectinoides, *Lamk.*
Pecten æquivalvis, *Sow.*
Lima Hermanni, *Goldf.*
Ostrea Maccullochii, *Sow.*

Brachiopoda.

Terebratula Ruthenensis, *Rey.*
— perforata, *Piette.*
— Heyseana, *Deslong.*
Rhynchonella Boscensis, *Rey.*
Rhynchonella liasica, *Rey.*
— rimosa, *von Buch.*
Spiriferina verrucosa, *von Buch.*
— rostrata, *Schloth.*

Echinodermata.

Diademopsis Cotteaui, *Rey.*
Eugeniocrinus, sp.
Pentacrinus basaltiformis, *Mill.*

12. The Zone of Amaltheus spinatus.

Synonyms.—"Upper portion of the Micaceous Marls," De la Beche, 'Geol. Trans.,' 2nd ser., vol. ii, 1829. "Amaltheenthone" (pars sup.), Quenstedt, 'Flözgebirge,' p. 540, 1843. "Marnes à Plicatules," Marcou, 'Jura Salinois,' p. 51, 1846. "Region des *Amm. costatus*," Oppel, 'Mittl. Lias Schwabens,' p. 23, 1853. "Die Schichten des *Amm. spinatus*," Oppel, 'Juraformation,' p. 138, 1856. "*Spinatus*-bed," Wright, 'Quart. Journ. Geol. Soc.,' vol. xiv, p. 25, 1858. "Thone mit *Amm. spinatus*," Ewald, 'Sitz. d. Berl. Akad., p. 349, 1859. "Horizont von *Amm. spinatus*," Wagener, 'Lias von Falkenhagen,' 1860. "Zone of *Amm. spinatus*," Wright, 'Fossil Asteroidea, Palæont. Soc.,'

vol. 1862. "Zone des *Am. spinatus*," Schlönbach, 'Eisenstein des mittl. Lias.,' p. 489, 1863. "Schichten des *Am. spinatus*," Emerson, 'Die Liasmulde von Markoldendorf,' p. 35, 1870. "Zone à *Pecten æquivalvis*" (pars sup.), Dumortier, 'Études Pal. Bassin du Rhône,' tom. iii, p. 213, 1869. "Marlstone Rock-bed" (pars), Judd, "Mem. on the Geol. of Rutland," 'Mem. of Geol. Survey,' 1875. "Zone of *Am. spinatus*," Tate and Blake, 'Yorkshire Lias,' p. 118, 1876. "*The spinatus zone*," Rev. Dr. Fred. Smithe, 'Trans. Cotteswold Nat. Club for 1876,' p. 349.

The bed with *Amaltheus spinatus* is so closely united with the zone of *Amal. margaritatus* that it appears to form the upper part of the Marlstone Rock-bed in the Midland Counties. It in general consists of a light-coloured, friable, sandy marlstone, containing many nodules, rock fragments, and fossiliferous concretions which form inconstant bands in the mass of the strata, and yield a considerable number of organic remains at Grettan, Alderton, and Churchdown Hills. I have collected *Amaltheus spinatus*, *Belemnites breviformis*, *Lima Hermanni*, *Terebratula punctata*, and *Spiriferina rostrata* from these nodules.

At Down Cliff, on the coast of Dorset, the *Spinatus*-beds form the uppermost portion of the Micaceous Marls of De la Beche. They consist of brown sands and sandstones in which *Amaltheus spinatus* is the characteristic Cephalopod, and with it many Gastropods and other fossils; the light-brown sands are overlain by non-fossiliferous clay, on which rests a remarkable bed of Marlstone containing a great number of Gastropods, with their shells in a fine state of preservation; as the rock is very hard and ferruginous these beautiful fossils are extracted with difficulty. I have collected from this bed *Amaltheus spinatus*, Brug., *Belemnites breviformis*, Voltz., *Pleurotomaria precatoria*, Deslong. *P. bitorquata*, Deslong., *P. rustica*, Deslong., *P. mirabilis*, Deslong., *P. procera*, d'Orb., *Cryptænia expansa*, Sow., *Straparollus sinister*, d'Orb.; and resting on this remarkable conglomerate of well-preserved shells are beds of Upper Lias Limestone, with *Harpoceras serpentinum*, Rein., *Harp. radians*, Rein., and *Harp. Holandrei*, d'Orb. So closely do these strata repose upon the Middle Lias fauna of the *Spinatus*-zone that they all appear to belong to the same bed.

In Yorkshire the upper portion of the Middle Lias consists of argillaceous shales with bands of ironstone, some of these belong to the *Margaritatus*, others to the *Spinatus*-beds; the workable beds of liassic ironstone are now ascertained to be found only in these two horizons. The *Spinatus*-beds are well seen at Hawsker bottoms, where *Am. spinatus* = *Hawskerensis*, Simp., is found in beds of red ironstone doggers, the probable equivalent of the Cleveland main seam, as well as in shale interstratified therewith. Another section of the zone is found at Kettleness, where the beds form the base of the cliff, and at Old Nab, where the strata are very fossiliferous, and exhibit a fine profile of the whole. The following section was carefully measured by MM. Tate and Blake,[1] as it affords a good type of the ironstone series of the Yorkshire coast.

[1] 'Yorkshire Lias,' p. 130.

Section of the Ironstone series at old Nab, near Staithes.

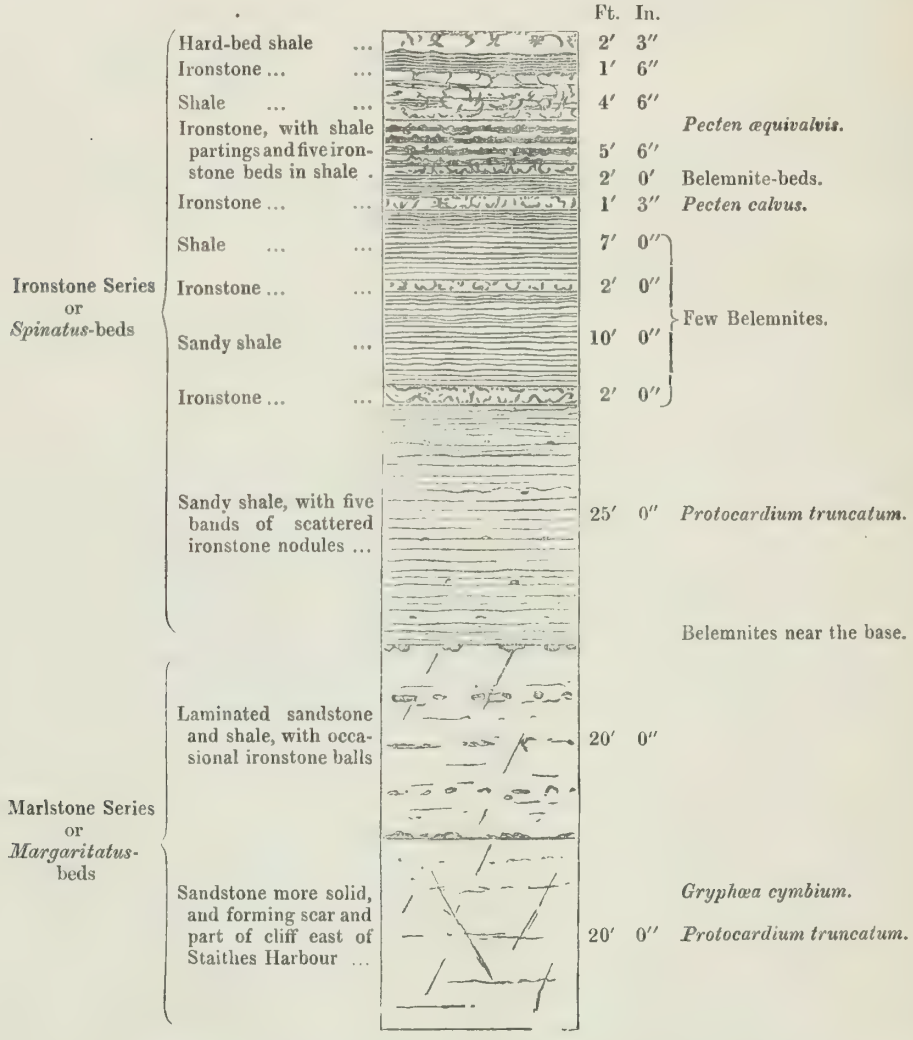
No.	Petrology.	Thickness. ft.	in.	Organic Contents.
1	Black, micaceous, marly shales, with a row of limestone balls	1	5	*Pleuromya costata, Pecten æquivalvis, Pholadomya costata, Pinna spathulata.*
2	Laminated shales	0	9	
3	Friable sandy shales, with limestone nodules at the bottom	1	6	*Pleuromya costata, Rhynchonella lineata.*
4	Greyish-brown marly sandstone	0	6	*Amal. spinatus, Pleuromya costata, Pholadomya costata, Pecten æquivalvis, Unicardium subglobosum, Modiola scalprum, Limea acuticosta, Protocardium truncatum, Rhynchonella tetraëdra.*
5	Sandy marl	3	6	
6	Top block of main seam surface, covered with small branching fucoids	3	0	*Amal. spinatus, Pecten æquivalvis, P. lunularis, P. substriatus, Unicardium janthe, Pleuromya rostrata, R. lineata.*
7	Shale	1	0	
8	Bottom block of main seam, surface covered with long tortuous fucoids	2	2	
9	Shale	0	8	*Pholadomya ambigua, Plicatula spinosa, Ostrea submargaritacea, Rhynchonella lineata.*
10	Ironstone	0	4	
11	Shale	0	6	
12	Ironstone	0	4	
13	Shale	0	6	
14	Ironstone	0	7	*Belemnites breviformis.*
15	Shale	0	10	*Belem. breviformis, Pecten æquivalvis, Monotis cygnipes.*
16	Ironstone	0	6	*Monotis cygnipes, Arcomya arcacea, Ostrea submargaritacea, Rhynchonella tetraedra.*
17	Shale with a ferruginous parting or narrow ironstone band	0	8	*Pecten æquivalvis, P. lunularis, Monotis cygnipes, Plicatula spinosa, Rhynchonella calcicosta, Waldheimia punctata.*
18	Ironstone	0	5	*Lima Hermanni, Rhynchonella tetraedra.*
19	Marly shale	2	6	*Pecten æquivalvis.*
	Total	21	8	
	Zone of *Amaltheus margaritatus.*			
20	Bottom seam of ironstone.			

My much esteemed friend, the late Professor John Phillips, F.R.S.,[1] who had often examined the Yorkshire Coast with great care, observed that "the Ironstone courses, which have been worked to some extent, may be examined with the greatest advantage in the cliffs and on the shore to the eastward of Staithes, for a space of three fourths of a mile, with . . . the superincumbent shales" in natural position. "These present hard shales, with septaria and petroleum, jet rock and hard shale below it, and softer shales enclosing one hard bed, which elsewhere is ironstone. Then the ordinary ironstone bands appear. These,

[1] 'Geology of Yorkshire; the Yorkshire Coast,' 3rd edition, p. 156, 1875.

examined on five different occasions, have presented some local differences, partly laid bare in the working, partly by waste of the coast." The alternations of shale and ironstone, with sandy shale forming the Ironstone series or *Spinatus*-beds, and the laminated sandstone shale, with occasional ironstone balls, forming the Marlstone series or *Margaritatus*-beds, are well seen in this section, which is intended to give a fair average idea of the whole when made in 1867.

FIG. 4.—*Section east of Staithes Harbour, Yorkshire Coast.*



"In the above section the Ironstone courses above the Marlstone are in all 16 feet 6 inches thick, and the shales above and below them (including the sandy portions below) are 45 feet 6 inches (including the hard-bed shale above the thicker Ironstones, 50 feet 6 inches). Total from 62 to 67 feet. The shales are in some places 8 to 10 feet thicker."[1]

[1] 'Yorkshire Coast,' p. 156.

On the south side of Portree Harbour, Isle of Skye, Professor Tate found the *Spinatus*-beds to consist of a hard, calcareous, yellowish-grey, thick-bedded sandstone, about 40 feet in thickness; the uppermost 5 feet of the Rock-bed is more bluish and calcareous, and appears to form the basement-bed of the Upper Lias; from these strata he collected the following Molluscan fauna.

Fossils from the Spinatus-zone at Portree, Skye.

Amaltheus spinatus, *Brug.*
— margaritatus, *Montf.*
Belemnites paxillosus, *Schloth.*
— elongatus, *Sow.*
— clavatus, *Blainv.*
— micrastylus, *Phil.*
Cryptænia expansa, *Sow.*
Pecten æquivalvis, *Sow.*
Lima Hermanni, *Voltz.*
Plicatula spinosa, *Sow.*
Avicula novemcostæ, *Brown.*
Gresslya Seebachii, *Brauns.*
Astarte Amalthei, *Quenst.*
Terebratula punctata, *Sow.*
Rhynchonella acuta, *Sow.*
Pecten liassinus, *Tate.*
Ostrea cymbium, *Lamk.*
Mytilus scalprum, *Sow.*
Cypricardia cucullata, *Munst.*
Waldheimia resupinata, *Sow.*
Rhynchonella tetraedra, *Sow.*
Pentacrinus Amalthei, *Quenst.*
Ditrypa quinquesulcata, *Münst.*

Palæontology of the Zone of Amaltheus spinatus.

VERTEBRATA.

Plesiosaurus, sp.
Ichthyosaurus, sp.

CEPHALOPODA.

Amaltheus spinatus, *Brug.*
— Engelhardti, *d'Orbig.*
— margaritatus, *Mont.*
Phylloceras zetes, *d'Orbig.*
Stephanoceras Holandrei, *d'Orbig.*
Belemnites clavatus, *Blainv.*
— apicicurvatus, *Blainv.*
— vulgaris, *Young & Bird.*
Belemnites cylindricus, *Simp.*
— paxillosus, *Schlot.*
— longiformis, *Blake.*
— compressus, *Stahl.*
— breviformis, *Voltz.*
— rudis, *Phil.*
— microstylus, *Phil.*

GASTEROPODA.

Cerithium acriculum, *Tate.*
— liassicum, *Moore.*
Chemnitzia Blainvillei, *Münst.*
— semitecta, *Tate.*
— nuda, *Münst.*
Cryptænia consobrina, *Tate.*
— expansa, *Sow.*
Dentalium elongatum, *Münst.*
Eucyclus conspersus, *Tate.*
— undulatus, *Phil.*
— cingendus, *Tate.*
— nireus, *d'Orbig.*
Nerita alternans, *Tate.*
Pitonnillus turbinatus, *Tate.*

Pleurotomaria helicinoides, *Römer.*
— rustica, *Deslong.*
— undosa, *Deslong.*
— similis, *Sow.*
Turbo latilabrus, *Stoliczka.*
Turbo lineatus, *Moore.*
— cyclostoma, *Benz.*
— aciculus, *Stolicza.*
Actæonina Ilminsterensis, *Moore.*
— chrysalis, *Tate.*

Lamellibranchiata.

Ostrea sportella, *Dumort.*
— submargaritacea, *Brauns.*
Anomia numismalis, *Quenst.*
Pecten æquivalvis, *Sow.*
— lunularis, *Römer.*
— verticillus, *Stoliczka.*
— substriatus, *Römer.*
Hinnites tumidus, *Ziet.*
Lima eucharis, *d'Orbig.*
— Hermanni, *Voltz.*
Limea acuticosta, *Münst.*
— Juliana, *Dumort.*
Plicatula spinosa, *Sow.*
— calva, *Deslong.*
Monotis inæquivalvis, *Sow.*
— cygnipes, *Young & Bird.*
— substriatus, *Münst.*
— calva, *Schlönb.*
— papyria, *Quenst.*
Inoceramus substriatus, *Münst.*
Perna Lugdunensis, *Dumort.*
Pinna spathulata, *Tate.*
Modiola scalprum, *Sow.*
— Thiollieri, *Dumort.*
— numismalis, *Oppel.*
Mytilus Aviothensis, *Buvig.*
Nucula cordata, *Goldf.*
Macrodon Clevelandicus, *Tate.*
— intermedius, *Simp.*
— Buckmani, *Rich.*
Leda subovalis, *Goldf.*
Leda Galathea, *d'Orb.*
— graphica, *Tate.*
Astarte striato-sulcata, *Römer.*
— rugata, *Quenst.*
Lucina pumila, *Münst.*
Cardita multicosta, *Phil.*
Protocardium truncatum, *Sow.*
Cardinia lævis, *Young & Bird.*
Cypricardia cucullata, *Münst.*
Myoconcha decorata, *Münst.*
Hippopodium gigas, *Tate.*
Trigonia Lingonensis, *Dumort.*
Tancredia Broliensis, *Buvig.*
— lucida, *Terq.*
— longicostata, *Buvig.*
Tellina Lingonensis, *Dumort.*
— fabulis, *Simp.*
Unicardium subglobosum, *Tate.*
Pholadomya ambigua, *Sow.*
— Simpsoni, *Tate.*
— lunata, *Simp.*
Goniomya hybrida, *Münst.*
Pleuromya costata, *Young & Bird.*
Gresslya intermedia, *Simp.*
Arcomya areacea, *Seebach.*
— concinna, *Tate.*
— longa, *Buvig.*
Ceromya bombax, *Quenst.*
— petricosa, *Simp.*
— sublævis, *Tate.*
Thoracia Grotiana, *Brauns.*

Brachiopoda.

Lingula sacculus, *Chapius.*
Spiriferina Walcotti, *Sow.*
— Signiensis, *Buvig.*
Waldheimia punctata, *Sow.*
— resupinata, *Sow.*
Rhynchonella tetraedra, *Sow.*
Rhynchonella lineata, *Young & Bird.*
— acuta, *Sow.*
— capitula, *Tate.*
— fodinalis, *Tate.*
— calcicosta, *Quenst.*

ANNELIDA.

Ditrypa circinata, *Tate*.
— capitata, *Phil*.
Ditrypa quinquesulcata, *Münst*.
Serpula limax, *Goldf*.

ECHINODERMATA.

Pentacrinus, sp.
Cidaris amalthei, *Quenst*.
Rhabdocidaris, spine.

Foreign Correlations.—Dr. Oppel[1] has shown that the upper half of the Swabian Middle Lias admits of the following division:

Upper Lias—*Posidonomya*-beds.

Horizons.	Petrology.	Thickness.	Organic Remains.
		feet.	
Amaltheus spinatus beds	Light argillaceous marly strata, alternating with clays	6—8	*Amal. spinatus, Belemnites breviformis, B. crassus, Lima Hermanni, Spiriferina rostrata, Rhynchonella quinqueplicata, Wald. punctata, Wald. subovoides.*
Upper Margaritatus beds	Blue clay with geodes, pyritic nodules, and separate argillaceous marly strata	45	*Amal. margaritatus, Phylloceras zetes, Belemnites paxillosus, Bel. compressus, Chemnitzia undulata, Turbo paludinæformis, Leda acuminata, Pentacrinus lævis.*
Under Margaritatus beds	Bluish clay, with argillaceous marls	10	*Lyt. fimbriatus, Aeg. globosus, Harpoceras Normannianum, Belemnites umbilicatus, B. elongatus, B. longissimus.*
Amaltheus margaritatus begins here.			
Henleyi-bed.	*Aegoceras Henleyi. Inoceramus ventricosus.*		

The Petrology of the *Spinatus*-bed in Swabia differs from the blue clays of the *Margaritatus*-bed on which the lighter argillaceous Marls rest, and the organic remains have enabled Dr. Oppel to define their limits, as he has done in the above profile.

In North Germany, Dr. U. Schlönbach[2] adopted a division of the upper portion of the Middle Lias, which closely resembles the preceding section of the South German series, and this careful observer has given a very instructive profile of an Ironstone exposure near Liebenburg, where the *spinatus* were found to be very distinct from the *margaritatus* beds.

[1] 'Jura Formation,' p. 139, 1856.

[2] "Den Eisenstein des mittleren Lias N.W. Deutschland," 'Zeitsch d. Deutschen geol. Gesellsch. Jahrg.,' vol. xv, p. 489, 1863.

HILS-EISENSTEIN, MIDDLE LIAS, NEAR LIEBENBERG.

HORIZONS.	PETROLOGY.	THICKNESS.	ORGANIC REMAINS.
SPINATUS bed.	Thick grey and brownish clay, with ironstone nodules and "Nagelkalk Schichten."	feet.	Appears to be non-fossiliferous.
	Greyish-blue clay	15	*Amaltheus spinatus* only, and very abundant in upper half.
Upper MARGARITATUS bed	Greyish-blue clay	15	*Amal. margaritatus* abundant; *Belemnites compressus* in the lower part.
Lower MARGARITATUS and HENLEYI beds	Grey, somewhat oolitic limestone, not very hard, half a mètre thick.....	1 8	*Amal. margaritatus, Phylloceras Loscombi, Lyt. fimbriatum, Aeg. Henleyi, Belemnites paxillosus, Bel. clavatus, Pleurotomaria granosa, Rhynchonella triplicata, Terebratula numismalis.*
RARICOSTATUS and OBTUSUS beds	Thick blue clay, with separate rocky bands laid close on one another	?	*Aegoceras planicosta, Aeg. Ziphus, Aeg. lacunatum, Arietites raricostatus, Belemnites acutus.*
	Marly limestone band	?	
SEMICOSTATUS beds	Thick blue clay, in parts speckled with reddish points	?	*Arietites semicostatus, = geometricus, Led. Romani.*
BUCKLANDI beds	Thick bluish-grey clay with geodes, above alternating with reddish-brown clay	?	
ANGULATUM beds	Small compact limestone bed with Cardinias and other Mollusca	?	*Aegoceras angulatum, Cardinia concinna.*
ANGULATUM beds	Sandy clays and shales, passing downwards into blue clay	?	*Aegoceras angulatum.*
PLANORBIS beds	Greyish-blue sandy limestone	?	*Aegoceras Johnstoni, Pecten Hehli, Lima succincta, Pinna Hartmanni.*

The entire thickness of the Lias in this section attains at least from 110 to 120 mètres.

Dr. Emerson found the *Spinatus*-Schichten well exposed at Lüthorst, near Markoldendorf, and in a soft, greyish, shaley clay he collected *Amaltheus spinatus*, Brug., *Belemnites clavatus*, Mill., *Turbo paludinæformis*, Schüb. The rich Ammonite-ironstone, which was formerly worked between Lüthorst and Hünnesrück, probably belonged to this zone.

A. von Strombeck[2] described the upper beds of the Amaltheenthone with *Amal. spinatus* in the Helmsted Jura; and Senator H. Römer found the same in his garden near Hildesheim with *Amal. spinatus*, *Gresslya ventricosa*, *Limea acuticosta*, and *Pecten æquivalvis*. Other localities described in the works of Ewald, Bornemann, and Wagener, might be enumerated to show that this upper portion of the Amaltheenthone is widely distributed in North Germany.

In France Professor E. Deslongchamps[3] gives a good profile of the Lias à Belemnites near Caen, in which we find (No. 4) the thick limestone separated by thin argilo-calcareous layers with *Aegoceras Bechei*, *Lytoceras fimbriatum*, *Belemnites clavatus*, *Gryphæa cymbium*, *Terebratula subovoides*, *Wald. punctata*, *Rhyn. tetraedra*, *Rhyn. rimosa*, and *Spiriferina rostrata*. This bed is overlain by (No. 5) a bank of sandy limestone, in part finely oolitic, containing *Amal. spinatus*, *Amal. margaritatus*, *Belemnites niger*, *B. arcuarius*, *Pleurotomaria suturalis*, *Pecten æquivalvis*, *P. disciformis*, *Gryphæa cymbium*, *Terebratula quadrifida*, *T. punctata*, *T. Edwardsii*, *Rhyn. tetraedra*, and *Spiriferina rostrata*. This appears to be the equivalent of the Marlstone rock-bed of English authors, as it is overlain by (No. 6) the Couche à Leptæna, which, as we shall presently learn, forms the lower bed of the Upper Lias. *Amaltheus spinatus* is collected in other localities in Calvados; and is found likewise at Avesnes, Doubs, at Saint-Amand Cher; at Grundershofen and Selzbrunnen, Bas Rhin; in the Departments of Meurthe, Moselle, Lozere, Haute-Saône, and Aveyron. In the Jura Department Marcou separated his "*Marnes à Plicatules*," with *Amal. spinatus*, *Belemnites Bruguerianus*, *Lima Hermanni*, *Plicatula spinosa*, *Gryphæa cymbium*, from the underlying beds containing *Amal. margaritatus*, and was the first to point out the important differences which exist between these two zones.

In Luxembourg *Amal. spinatus* has been collected from the "*Macigno d'Aubange*," near Athus, which is considered by Chapuis and Dewalque[4] as the equivalent of the Marlstone and ironstone of English authors.

Dumortier[5] says that *Amal. spinatus* is found only in the uppermost portion of the Middle Lias, in the horizon of *Limea acuticosta*, where it is accompanied by *Avicula*

[1] "Die Liasmulde von Markoldendorf;" 'Zeitsch. d. Deutschen geol. Gesellsch.' Jahrg., 1870, p. 303, vol. xxii.

[2] 'Geognost. Karte des Herzog. Braunschweig,' 1856.

[3] 'Études Jurassiques Infér. de Normandie,' pp. 59—60, 1864.

[4] 'Fossiles des Terr. second. de Luxembourg,' p. 12, 1853.

[5] 'Études Paléont. du Bassin du Rhône,' tom. iii, p. 213, 1869.

cygnipes and *Cardinia crassissima*; and he observes that the appearance of this beautiful species has only an instant of duration in time, for in all the Basin of the Rhone it occupies only a very limited vertical space, whilst the remains of *Amaltheus margaritatus* fills nearly all the enormous thickness of the Middle Lias.

Table showing the extension of the Middle Lias in the British Islands, Belgium, France, Switzerland, Germany, Austria, and Italy, with indications of the Liasian Ammonite-zones found in some typical regions of the European area.[1]

Ammonite-zones of the Middle Lias.	British Islands.			Belgium.	France, Departments of.						Switzerland.		Germany.		Austria.	Italy.
	England.	Ireland.	Scotland.	Luxemburg.	Normandy.	Côte-d'Or.	Yonne.	Cher.	Jura.	Aveyron.	Basel.	Argau.	Hanover.	Württemberg.	N. E. Alps.	Lombardy.
SPINATUS	*	...	*	*	*	*	...	*	*	*	...	...	*	*	...	*
MARGARITATUS	*	...	*	...	*	*	*	*	*	*	...	*	*	*	*	*
HENLEYI	*	...	*	...	*	*	*	*	*	*	*	*	*	*	*	*
IBEX	*	*	...	...	*	*	*	*	...	*	...	*	*	*	*	...
JAMESONI	*	*	*	*	*	*	...	*	...	*	...	*	*	*	*	*
ARMATUM	*	*	*	...	...	*	...	*	...	...	...	...	*	*		...

In the above table I have separated the *Armatum* from the *Jamesoni* zone, although united with it in the text, because the stratum with *Aegoceras armatum* forms a good Ammonite-zone, although most of its other Molluscan Fauna ascend into higher beds. When the *Armatum*-group is described and figured it will be shown that a most interesting series of forms range themselves around the original Sowerbyan type, although differing in many specific characters from that Ammonite; the whole forming a remarkable assemblage of the Aegoceratidæ, which appeared with the dawn of the Middle Lias, and had, it would seem, a very limited life in time.

[1] In addition to the works already cited in the description of the different zones of the Middle Lias on the European Continent I have to add 'Géologie der Schweiz,' by Professor B. Studer, Zurich, 1851; 'Die Cephalopoden aus dem Lias der Nordöstlichen Alpen,'' by Franz Ritter von Hauer, Wien, 1856; 'Studii geologici et paleontologici sulla Lombardia,' by Stoppani, Milan, 1857; 'Der Jura in Franken, Schwaben, und der Schweiz, verglichen nach seinen palæontologischen Horizonten,' by Dr. W. Waagen, Munich, 1864.

A Table showing the stratigraphical distribution of the Ammonoida in the Middle Lias of the British Islands.

Families, Genera, and Species.	Armatum.[1]	Jamesoni.	Ibex.	Henleyi.	Margaritatus.	Spinatus.
Family—Aegoceratidæ.						
Genus—Aegoceras.						
Aegoceras armatum, *Sow.*	*					
— densinodum, *Quenst.*	*					
— submuticum, *Oppel*	*					
— Jamesoni, *Sow.*	...	*				
— brevispinum, *Sow.*	...	*				
— Taylori, *Sow.*	...	*				
— pettos, *Quenst.*	...	*				
— Valdani, *d'Orbig.*	...	...	*			
— Maugenesti, *d'Orbig*	...	...	*			
— Henleyi, *Sow.*	...	...		*		
— striatum, *Reinecke*	...	...		*		
— Bechei, *Sow.*	...	...		*		
— curvicornum, *Schlönb.*	...	...		*		
— Davœi, *Sow.*	...	...		*		
Family—Arcestidæ.						
Genus—Amaltheus.						
Amaltheus Ibex, *Quenst.*	...	...	*			
— margaritatus, *Montf.*	...	...	...	...	*	
— Engelhardti, *d'Orbig.*	...	...	...	...	*	
— spinatus, *Brug.*	...	...	...	...	...	*
Family—Lytoceratidæ.						
Genus—Phylloceras.						
Phylloceras Loscombi, *Sow.*	...	...	*	*		
— Zetes, *d'Orbig*	...	...	...	...	*	*
Genus—Lytoceras.						
Lytoceras fimbriatum, *Sow.*	...	...	*	*	*	
— lineatum, *Schloth.*	...	...	...	*		

[1] In this table I have separated the *Armatum* from the *Jamesoni* zone, because *Aeg. armatum* and its allied forms are limited in their range to the lowest portion of the latter, and are the most characteristic fossils of the basement bed of the Middle Lias.

THE UPPER LIAS.

I include in the Upper Lias all the argillaceous, shaley, laminated, marly, and arenaceous deposits interposed between the *Spinatus*-beds of the Middle Lias, and the basement-beds of the Inferior Oolite, containing *Harpoceras Murchisonæ*. This group of strata nearly corresponds to the "*Posidonienschiefer mit Stinksteinen*" and "*Lichtgraue Kalkmergel mit Ammonites jurensis*" of Professor Quenstedt,[1] and the "*Neuvième Étage; Toarcien*" of the late Professor Alcide d'Orbigny.[2]

The Upper Lias exhibits great differences in thickness as we follow the beds northwards through the midland districts of England, in some parts of which it measures 300 feet, but rapidly diminishes in North Oxfordshire to 30, and disappears entirely in the south of that county. In South Lincolnshire it attains 200 feet, and thins away entirely in South Yorkshire, whilst in North-East Yorkshire it thickens out again, and forms some fine bold instructive sections on the Yorkshire coast.

The Petrology of this group, which in some parts of Gloucestershire is upwards of 300 feet in thickness, enables us to subdivide it into a lower portion, consisting of dark argillaceous, shaley, or thinly laminated beds, and an upper portion composed of marly, ferruginous strata, or fine yellowish and brownish sands.

By a careful study of the Palæontology of the Upper Lias I have been able to distinguish among the numerous organisms contained therein four faunas, having several well-defined species characteristic of each. The details of each of these zones will be given in the sequel.

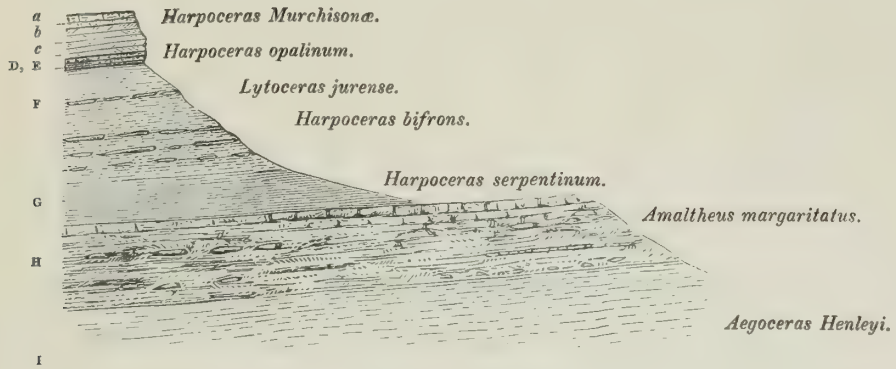
It is very difficult to find a section in which all the zones are present and exposed in their natural sequence, so I select that of Frocester Hill, near Stonehouse, between Gloucester and Bristol, on the Midland Railway, as the best I know.

All the divisions of the Upper Lias are here seen *in sitú*, and may be satisfactorily studied in one day's work; and this instructive section may be afterwards advantageously compared with other exposures of the Liassic sands forming the *Jurense*-zone at Haresfield Beacon, a mile and a half from the railway-station, and at an elevation of 700 feet above the sea; in lane cuttings near Nailsworth; in sections at Uley Bury; Stinchcombe Hill; Wotton-under-Edge; and along Ozleworth Bottom; all localities of easy access, in which are well displayed the Liassic sands, and at the same time affording magnificent pictures of the vale scenery of Gloucestershire.

[1] 'Flötzgebirge Würtembergs,' pp. 213 and 267, 1843.

[2] 'Cours Élément. de Paléontologie et de Géologie stratigraphiques,' tom. ii, p. 463, 1852.

Fig. 5.—*Section of Frocester Hill, near Stonehouse, between Gloucester and Bristol, Midland Railway.*



a, *b*, *c*. Inferior Oolite; 70 feet = zone of *Harpoceras Murchisonæ*.

D, E. Calcareo-ferruginous sandstone (Cephalopoda bed); 6 feet { zones of *Harpoceras opalinum* and *Lytoceras jurense*.

F. Grey, yellow and brown sands, with inconstant and concretionary bands of calcareous sandstone; 150 feet? = zone of *Harpoceras bifrons*.

G. Upper Lias shale; 80 feet = zone of *Harpoceras serpentinum*.

H. Marlstone; hard calcareous sandstone, resting on brown and grey sands, with bands and nodules of ferruginous sandstone; 150 feet = zone of *Amaltheus margaritatus*.

I. Middle Lias shale = zone of *Aegoceras Henleyi*.

Inferior Oolite.

		Ft.	in.
a.	A fine-grained oolitic limestone, similar to the freestones of Birdlip, Painswick, and Leckhampton Hills; the upper beds exhibit a most remarkable example of oblique bedding, the flaggy layers of which rest horizontally on inclined beds of freestone; thickness about	50	0
b.	A coarse, light, cream-coloured, gritty, crystalline oolite, traversed at intervals by extremely crystalline shelly layers; a great part of the rock appears to be composed of fragments and plates of Crinoidal plates and spines of *Echinidæ*, and comminuted fragments of the shells of *Mollusca*. This white rock has a most remarkable lithological character, and glistens brilliantly when lit up by the sun's rays. The shelly and pisolitic seams which traverse this bed resemble those in the Pea-grit. The surface of weathered slabs exposes numerous microscopic objects; the rock, in fact, is almost entirely composed of organic *débris*, and measures about	10	0
c.	A hard, fine-grained, oolitic, sandy limestone, of a light brown colour, lithologically different from *b*. It contains many fossil shells, which are extracted with difficulty, and passes into a hard yellow oolite with few fossils, attaining a thickness of from	8 to 10	0

[The lithological character of this rock is very different to that of *d*, on which it rests.]

The Cephalopoda Bed—Upper Lias.

Zones of Harpoceras opalinum and Lytoceras jurense.

		Ft.	in.
D.	A coarse, dark-brown, calcareo-siliceous rock, full of small, dark, flattened grains of hydrate of iron. It contains an immense quantity of fossils, but *Ammonites* and *Belemnites* are the dominant forms; some of the bivalve shells are well preserved; the matrix adheres to their surfaces with such tenacity that they can seldom be cleaned without injury. The *Ammonites* and *Nautili*, for the most part, want the shell. *Harpoceras opalinum* and *Rhynchonella cynocephala* lie in the upper part of the bed, and *Lytoceras jurense*, *Harpoceras insigne*, *Harp. variabile*, *Harp. striatulum*, *Belemnites*, *Nautili*, and other *Mollusca* in the middle part; the lower part is not so fossiliferous; this bed measures	4	6

Zone of Harpoceras bifrons.

E.	A hard, coarse, brown mudstone, with hard irregular nodules of a calcareo-siliceous sandstone, highly micaceous and ferruginous, and passing downwards into the sands	0	9
F.	Fine, brown and yellowish, micaceous sands, passing into greyish coloured micaceous sands, with inconstant and concretionary bands of highly calcareous sandstone; nodules of various sizes occur in these bands, which are sometimes fossiliferous, containing chiefly *Harpoceras bifrons* in nodules with *Belemnites*	150?	

Zone of Harpoceras serpentinum.

G.	Blue clay and shale, marked by the outburst of springs and by pools of water on the terrace formed by the Upper Lias Clay	80	0

Middle Lias.

Zone of Amaltheus margaritatus.

H.	Marlstone; a hard calcareous sandstone, resting on brown and grey sands, with bands and nodules of ferruginous sandstone	150	0

Zone of Aegoceras Henleyi.

I. The shales of the Middle and Lower Lias, sloping down into the valley.

13.[1] The Zone of Harpoceras serpentinum.

Synonyms.—"Alum shale," Young and Bird, 'Geol. of York.,' p. 133, 1822. "Upper Lias," part, of English authors. "Posidonien-Schiefer," Römer, 'Oolit. Geb.,' p. 5, 1836. "Lias-Schiefer," von Buch, 'Jura Deutsch.,' "Berl. Akadem," 1837. "Posidonien-Schiefer," Quenst., 'Flötzgebirge,' p. 538, 1843. "9^{e} Étage, Toarcien (pars infér.)," d'Orbigny, 'Cours. Élément. de Paléontol.,' p. 463, 1852. "Die Schichten der *Posidonomya Bronni*," pars, Oppel, 'Juraformation,' p. 197, 1856. "Communis-bed," Wright, 'Quart. Journ. Geol. Soc.,' vol xiv, p. 25, 1858. "Communis Zone," Rev. Dr. Smithe, 'Cots. Club Trans.,' Aug., 1861. 'Serpentinus-bed,' Judd, 'Geology

[1] The zone of *Stephanoceras commune*, named in p. 3, may be advantageously divided into the zones of *Harpoceras serpentinum*, and *Harpoceras bifrons*.

of Rutland,' p. 79, 1875. "Jet Rock series = Zone of Ammonites serpentinus," Tate and Blake, 'Yorkshire Lias,' p. 73, 1876.

The argillaceous beds of this zone in Gloucestershire consist of bluish clay, containing occasional and irregular bands of nodular argillaceous limestone resembling "cement-stones." In the escarpments of the Cotteswold Hills the *Serpentinum*-zone of the Upper Lias attains in some places a thickness of 80 feet, interposed between the Marlstone or rock-bed of the *Margaritatus*-zone and the beds with *Harpoceras bifrons*. The Upper Lias clay is generally concealed by *débris* derived from the Oolitic strata, and its position is therefore most readily ascertained by surface indications, such as springs and marshes. This clay-bed forms the retentive water-bearing stratum at the base of the superincumbent porous strata, so that the rain, which falls upon the table-land of the Cotteswold Hills, after saturating the Oolitic rocks and subjacent sands, bursts forth as springs along their slopes and escarpments, at the junction of these beds with the impervious clay. All the springs in this district arising from the drainage of the Inferior Oolite have their origin in this arrangement of the strata, and break out as sources at an elevation of about 700 feet above the level of the sea.

On the summits of Bredon, Alderton, Gretton, and Churchdown Hills, all outliers of the Cotteswolds, we find sections of the *Serpentinum* beds, which consist in general of the following subdivisions:

1st. Brown marly clays of variable thickness, according to the extent of denudation of the upper beds; they contain many of the fossils of our list.

2nd. A band of nodular argillaceous limestone, from six to eight inches in thickness, called the "Fish-bed;" this stratum has yielded many interesting remains. I obtained from a nodule at Gretton a large and nearly perfect specimen of *Pachycormus latirostris*, Ag., and from nodules at Alderton, Dumbleton, and Gretton have been extracted *Leptolepis concentricus*, Egert., *Tetragonolepis discus*, Egert. Wings and elytra of Insects have been found in nodules at Dumbleton and Gretton, of which the most remarkable is a fine Neuropterous wing belonging to *Libellula Brodiei*, Buck.

3rd. Is a thick bed of bluish mottled clay, several feet in thickness, and more or less laminated, at Alderton, where I saw it many years ago well exposed; it contained a great many small Gastropods, among them were *Cerithium*, *Rostellaria*, *Trochus*, and *Natica*; of Lamellibranchs, I found *Arca*, *Leda*, and *Posidonomya*; of Echinoderms I observed *Acrosalenia crinifera*, Quenst., *Pseudodiadema Moorei*, Wrt., *Ophioderma*, n. sp., and fragments of *Pentacrinus*. The shells were compressed moulds, which looked beautiful when the clay was first split open, but as it dried, the fossils unfortunately broke into fragments and could not be preserved for specific determination.

4th. The Leptæna-bed, composed of a brown friable marl, one to two inches thick, contains many species of small Brachiopods, belonging to the genera *Leptæna*, *Spiriferina*, *Terebratula*, *Rhynchonella*, and is separated from the upper beds of the Marlstone by—

5th. A thin band of blue and yellow clay, containing many *Harpoceras falciferum*, Sow., *Belemnites acuarius*, Schloth., and *Rhynchonella pygmæa*, Moore. This bed rests upon the light-coloured marls of the *Spinatus*-stage.

From a railway cutting near Stroud, I obtained many fine specimens of *Harpoceras serpentinum*, Rein., and during the execution of works for drainage, and the formation of a new road near Nailsworth, good sections of the Upper Lias were exposed; from the bands of limestone numerous fossils were obtained, as *Stephanoceras commune*, Sow., *Harpoceras bifrons*, Brug., *Harp. falciferum*, Sow., *Phylloceras heterophyllum*, Sow., *Lytoceras cornucopiæ*, Young., *Harp. Lythense*, Young., *Belemnites compressus*, Voltz., *Nautilus latidorsatus*, d'Orbig., *Turbo capitaneus*, Münst., *Pleurotomaria sub-decorata*, Münst., *Astarte lurida*, Sow., *Posidonomya Bronni*, Voltz., *Nucula Hausmanni*, Roem., *Gresslya gregaria*, Roem., *Lima bellula*, Mor. and Lyc., *Lima gigantea*, Sow., *Tancredia læviuscula*, Lyc., and several undescribed forms.

The Rev. Dr. Smithe,[1] F.G.S., has given an interesting account of two quarries of Upper Lias, on the top of Churchdown Hill, and known as north and south, the latter being the larger and better of the two for its section. The beds are nearly horizontal, and exhibit only slight traces of disturbance.

Stephanoceras commune Zone at Churchdown.

No.	Petrology.	Thickness.	Organic Remains.
		ft. in.	
1	Alluvial soil	1 6	
2	Brown marly soil.....	2 0	Fish, Crustacea, and all the fossils of list.
3	Concretionary argillaceous limestone...	0 4–6	"Fish bed," *Leptolepis concentricus, Thrissops*, sp., *Stephanoceras commune, Posidonomya Bronni, Mytilus gryphoides.*
4	Blue and drab mottled clay.....	6 0	"Alga bed," fossils of No. 2, with *Algæ, Aptychi*, &c.
5	Brown marly shale	1 0	"Leptæna bed," *Spiriferina, Leptæna, Terebratula*, and *Rhynchonella, with Nucula* and other Lamellibranchs.
6	Blue and yellow clay	1 0	*Stephan. commune, Bel. acuarius, Rhyn. pygmæa, Terebrat. globulina.*
	Light-coloured "nodular bed," *Spinatus-zone*, containing Belemnites.		

We have in the above a replica of the Upper-Lias section so well shown at Ilminster, Somerset, and of that at Curcy, la Caine, Calvados, described by Professor Deslongchamps.[2]

[1] "The Geology of Churchdown Hill," 'Cotteswold Club,' August, 1861.

[2] 'Études sur les Étages Jurassiques Infer. de Normandie,' p. 75, 1864

The Upper Lias at Ilminster, Somerset, has become famous for the large number of species it has yielded to the long, patient, and careful investigations of Mr. Charles Moore, F.G.S., now of Bath, but formerly a resident in Ilminster, where he availed himself of exceptional advantages for making his collection. The following is the succession of the beds at Strawberry Bank, near Ilminster, described in descending order.[1]

Section of the Upper Lias at Strawberry Bank, Ilminster.

a. Yellow micaceous sands of the Inferior Oolite, unfossiliferous.

b. Eight bands of clay and stone, containing *Harpoceras Moorei = opalinum*, *Harp. variabile*, *Lytoceras insigne* = Zone of *Lytoceras jurense*.

c. Light blue clay, 4′ 6″, with *Crania Moorei*.

d. Three layers of drab-coloured clay and stone, *Belemnites Ilminsterensis*.

e. Alternate layers of light-grey clay and rubbly stone, containing *Harpoceras bifrons*, *Harp. radians*, *Harp. falciferum* = Zone of *Harpoceras bifrons*.

f. Blue mottled clay, with many Foraminifera.

g. Beds of rubbly stone and light-coloured clays, with *Harpoceras serpentinum*, *Stephanoceras commune*, *Stephan. fibulatum* = Zone of *Harp. serpentinum*.

h. Concretionary blue clay, with Foraminifera, and a layer of sandy stone, with *Rhynchonella Bouchardii*. These form the upper Cephalopoda-beds which overlie—

i. "The Saurian" and "Fish Beds" about twelve inches thick, which consist of a yellow septarian limestone, including Fishes in fine preservation, as *Pachychormus*, *Eugnathus*, *Lepidotus*, *Pholidophorus*, *Leptolepis*, *Dapedium*, and *Hybodus*. The Saurian remains are, *Ichthyosaurus acutirostris*, Owen, *Teleosaurus temporalis*, Blainville, *Teleosaurus Moorei*, Deslongchamps.

j. "The Leptæna-beds" consist of thin layers of yellowish clay, resting immediately on the Middle Lias, and forming the basement bed of the Upper Lias. They measure about eighteen inches in thickness, and contain *Leptæna Bouchardii*, *L. Moorei*, *Thecidium rusticum*, *Spiriferina Ilminsterensis*, *Zellania liassica*, *Leptæna granulosa*, *Alaria unispinosa*, and other Gastropods.

Mr. Moore's museum in the Philosophical Institution, Bath, contains *Teleosaurus*, *Ichthyosaurus*, and other Reptiles, and a magnificent collection of Fishes, representing many new species of *Pachycormus*, *Lepidotus*, and other Upper-Lias forms, in the finest possible preservation; the brown, enamelled scales of the fish beautifully contrasting with the pale yellow rock in which they are entombed. It was here likewise that the Leptæna-bed was first discovered in England, which contained so many interesting ancient forms of

[1] "Middle and Upper Lias of the South-west of England," 'Proc. of the Somerset Archæol. Soc.,' p. 16, vol. xiii, 1865-6.

small Brachiopods belonging to the genera *Leptæna*, *Spiriferina*, *Thecidium*, *Rhynchonella*, and *Terebratula*, together with a number of Gastropods and Lamellibranchs, amounting to upwards of 150 species. The *Leptæna*-bed forms a remarkable stratum, and was found by Professor E. Deslongchamps to occupy the same stratigraphical position at Curcy, la Caine, and other localities in Normandy, as it does in Somersetshire and Gloucestershire. The following note, January, 1862, from my learned friend Thomas Davidson, Esq., F.R.S., explains the discovery of the Lias *Leptænæ*: "When at Boulogne, in 1847, M. Bouchard received a parcel of fossils from the Lias of Pic de St. Loup, among which were several specimens of a small *Leptæna*, and about the same time I received a small parcel from Mr. C. Moore, among which I recognised two or three species of Lias *Leptæna*, which M. Bouchard and myself described, for the first time, in the 'Annals and Mag. of Natural History' for October, 1847. The discovery of the Lias *Leptænæ* is therefore due to M. Bouchard and Mr. Moore. It was my description and publication of these species which first directed public attention to the subject."

In Yorkshire the lower zones of the Upper Lias attain a remarkable development, and have long been found to contain jet-rock and alum-shale, and an immense number of organic remains in a fine state of preservation. I shall select two from among the coast sections which afford the most instructive exposures of these beds. The first is the cliffs and scars at Saltwick, south of Whitby. My old and esteemed friend, the late Professor John Phillips,[1] made a sketch of this locality, which I introduce with a few additions, as a faithful outline of this instructive bay, whose bold promontory and conspicuous island, formed of dark Lias, offer uncommon facilities for examining the whole section, and collecting from each bed its characteristic fossils. In descending from the encircling cliffs to the great hollow below, in which the alum-works were situated, we pass over—(1 and 2) the thick capping of the lower shales and sandstones, with remains of plants; (3) the dogger, a rough, uneven rock, with much ferruginous material in the mass, overlying (4) the *Leda ovum*-bed, which characterises the top of the alum-shale, and in which *Harpoceras bifrons*, *Harp. Lythense*, *Phylloceras heterophyllum*, *Phyll. subcarinatum*, *Stephanoceras commune*, *Stephan. fibulatum*, *Stephan. subarmatum*, and several other species of our list are found. This bed is about 34 feet thick, and overlies (5) a lumpy irregular band of nodules; beneath this (6) another bed of dark-grey alum-shale, containing an irregular band of nodules, but not many fossils, about 34 feet thick, and forming the lowest stratum worked for alum. It rests upon (7) a flat bed of ironestone, 4 inches thick, and very persistent in its character. Beneath the ironstone is (8) a bed of hard, dark alum-shale, 16 to 18 feet in thickness, which contains a great number of Belemnites entombed in two seams of shale, the one three feet below the ironstone, the second a foot from the bottom of the bed. *Belemnites vulgaris*, *Bel. subtenuis*, *Bel. tubularis*, *Bel. lævis*. Then follows (9) an irregular band of calcareous nodules, lumpy, spheroidal, or flattened, one foot thick. Beneath is (10) a dark, firm shale, with some

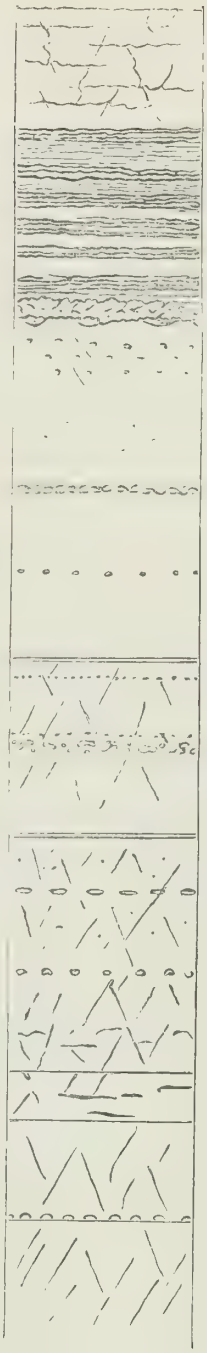
[1] 'Yorkshire Coast,' 3rd edit., p. 144, 1875.

Fig. 6.—Saltwick from the South.

Belemnites and few fossils, about 18 feet thick, and resting upon (11) a dark, hard, reddish, shale bed, changing into a ferruginous band, from 3 to 6 inches thick, and underlain by (12) hard, dark shales, 12 feet thick, containing *Belemnites subtenuis*, and *Inoceramus dubius;* a band of remarkable, flattened spheroidal balls (13) separates the above from the hard, dark shales of (14) the *Serpentinum*-zone, 20 feet thick, which underlie the above. There are many fossils in this lower zone, as *Harpoceras serpentinum, Harp. exaratum, Harp. ovatum, Harp. Levisoni, Belemnites tubularis, Inoceramus dubius,* and *Extracrinus Phillipsii.* Then (15) a band of pyritized, irregular balls, covering 20 feet of hard grey shales (16). Beneath is another bed of dark shale (17), with calcareous concretions and considerable portions of Jet; this rock stands firm against the sea, and is broken up by the workmen who mine it for Jet, which is here of good quality, and used in manufacture. Below the Jet-rock are 20 feet of hard shales with large nodules, which overlie 30 feet of soft shales, containing *Belem. cylindricus.*

[1] I have to thank Mr. William Smith, of Cheltenham, cousin and executor of the late Professor Phillips, F.R.S., for his kind permission to use the above, and two other woodcuts, from the Professor's last work on the 'Yorkshire Coast,' p. 145, 1875.

FIG. 7.—*Profile of Saltwick Nab, south of Whitby.*



No.		ft.	in.	
1.	Cap grit.			Irregularly stratified.
2.	Alternations of sandstone and shale.	60	0	Occasional coal-bands, with *Zamiaceæ.*
3.	Dogger, Inferior Oolite.	4	0	Ferruginous.
4.	Cement-nodules in the alum-shale.			*Harpoceras bifrons, Stephanoceras commune, Belemnites Voltzii, Leda ovum.*
5.	Lumpy bed.	34	0	
6.	Dark alum-shale, with irregular band of nodules. Lowest bed worked for alum.	34	0	Contains fossils.
7.	Thin, flat ironstone band.	0	4	Non-fossiliferous.
8.	Dark alum-shale, somewhat harder than the upper strata.	18	0	
9.	Double band of nodules.	1	0	*Harpoceras ovatum, Belemnites vulgaris.*
10.	Dark shale, with Belemnites.	18	0	Fossils rare, Belemnites top and bottom.
11.	Red shale bed.	0	6	
12.	Hard dark shale: fossils.	12	0	*Belemnites subtenuis, Inoceramus dubius.*
13.	Flattened spheroidal nodules.			
14.	Hard dark shales.	20	0	*Harpoceras serpentinum, Belemnites tubularis, Inoceramus dubius, Extracrinus Phillipsi,* Wright.
15.	Band of pyritic nodules.			
16.	Hard grey shales.	20	0	
		10	0	
17.	Jet-rock, hard shale.			*Belemnites tripartitus, Aptychus.*
18.	Hard shales.	20	0	
19.	Annulatus-bed of nodules.			*Stephanoceras annulatum.*
20.	Soft shales.	25	0	*Belemnites cylindricus.*

IRONSTONE SERIES OF THE MIDDLE LIAS.

Detailed description of the Saltwick Section.

No. 1. Sandstone rock belonging to the Lower Sandstone series.
2. Alternating beds of sandstone and shales, with remains of plants, chiefly *Zamiaceæ.* } 60 feet.
3. Rough ferruginous Dogger in Inferior Oolite, with inconstant bands formed of harder, more ferruginous, irregular, spheroidal masses of rock, 4 feet thick.
4. Grey alum-shale, the upper part a little sandy, with few or no fossils. At about 5 feet in depth layers of small limestone nodules appear, and continue for about that space in sufficient plenty to be worked for the making of "cement." Lower down the nodules are fewer, and admit of a larger proportion of carbonate of iron, alumina, and silica. The shale is pyritous, and abounds with fossils, as *Harpoceras bifrons, Stephanoceras commune, Belemnites Voltzii, Leda ovum, Gresslya donaciformis.* Thickness 34 feet.
5. A conspicuous, irregular band, occasionally swelling out into lumpy masses, more calcareous than most of the hard layers that occur below.
6. Dark alum-shale, 34 feet thick, with an irregular band of nodules. This bed is not rich in fossils, and appears to be the lowest bed worked for alum.
7. Is a thin flat bed of ironstone, somewhat remarkable for its continuity, 4 inches thick.
8. Dark alum-shale, 16 to 18 feet thick, somewhat harder than the strata above. The fossils are chiefly Belemnites, of which a kind of bed is formed 3 feet below No. 7. There is also another bed of Belemnites 1 foot from the bottom; both are of limited extent. *Monotis substriatus.*
9. An irregular, frequently double band of subcalcareous nodules, large and small, lumpy, spheroidal, or flattened, ½ to 1 foot.
10. Dark firm shale, 16 to 18 feet thick, poor in fossils; Belemnites occur near the top and bottom.
11. Hard, dark, reddened shale bed, occasionally changing to a ferruginous band, 3 to 6 inches thick.
12. Hard dark shales, 12 feet thick, containing *Belemnites subtenuis, Inoceramus dubius.*
13. Band of remarkable flattened spheroidal balls.
14. Hard dark shales, 20 feet thick, with numerous fossils, often pyritized, *Harpoceras Mulgravium, Belemnites tubularis, Inoceramus dubius, Extracrinus Phillipsii,* Wright.
15. Band of irregular balls, pyritized.
16. Hard grey shales, 20 feet.
17. Jet-rock, hard shale, 10 feet thick, with calcareous concretions and considerable portions of Jet. *Belemnites tripartitus, Aptychus,* &c.
18. Hard shales, with large nodules in the upper part, 20 feet.
19. *Stephanoceras annulatum* bed of nodules.
20. Soft shales, 20 to 30 feet thick, and containing *Belemnites cylindricus.*

Section of the Upper Lias at Rockliff, Easington Heights, north of Whitby, altitude 681 *feet above the level of the sea.*[1]

No.	Petrology.	Thickness.	Organic Remains.
		ft. in.	
1	Sandstone beds with plant-seams		*Zamiaceæ.*
2	Inferior Oolite, the Dogger		*Trigonia costata* and other Inferior-Oolite fossils.
	Alum-shale. Zone of *Harpoceras bifrons.*		
3	Dark grey shale	10 0	*Harpoceras bifrons, Harp. Lythense.*
4	Hard or Cement-stone Seam, numerous calcareous nodules, exclusively manufactured into Roman cement ...	25 0	*Stephanoceras commune, Steph. fibulatum, Steph. subarmatum, Lytoceras cornucopiæ, Phylloceras heterophyllum, Leda ovum, Trigonia literata, Gresslya donaciformis, Discina reflexa.*
5	Nodules in these and succeeding beds, highly ferruginous	150 0	*Belemnites subtenuis, Bel. vulgaris, Leda ovum.*
6	Lowest level worked for alum, 90 feet from the surface		
	Jet-rock. Zone of *Harpoceras serpentinum.*		
7	Many pyritous nodules, very much flattened	20 0	*Harpoceras serpentinum, Harpo. exaratum, Harpo. ovatum.*
8	Hard compact shale, very sandy, a few small nodules mostly barren in fossils	30 0	*Lepidotus, Pachychormus, Ptycholepis, Leptolepis, Gyrosteus mirabilis.*
	Middle Lias. Zone of *Amaltheus margaritatus.*		

Professor Judd[2] describes the Upper Lias of Rutland as occupying a large area in Sheet 64 of the 'Geological Survey.' This division of the Lias is usually concealed by Drift except on the steep slopes of the Oolitic escarpments, where it attains a thickness of about 200 feet, and consists almost entirely of clays, which Prof. Judd divides into the following beds. The section is in a descending order.

1. *The Leda-ovum Beds* form the highest beds of the Upper Lias, and consist of clays, with numerous layers of septaria, everywhere distinguished by the abundance of *Leda ovum*, Sow. The prevailing Ammonite is *Harpoceras bifrons*, which occurs in great numbers. Here are also *Stephanoceras commune, Steph. annulatum, Steph. crassum, Steph. fibulatum, Steph. Holandrei. Phylloceras heterophyllum*, is tolerably abundant, but

[1] Louis Hunton, 'Trans. Geol. Soc.,' vol. v, second series, p. 215, 1836.

[2] "Geology of Rutland," 'Memoirs of the Geological Survey,' p. 79, 1875.

species of the *Harpoceras* genus are comparatively rare. *Belemnites compressus, Gresslya donaciformis, Arca truncata,* and *Discina reflexa,* are also abundant.

2. *The Commune-Beds* are found at a little distance above the *Serpentinum*-beds; they are crowded with small specimens of *Steph. commune, Steph. annulatum, Belemnites irregularis, Astarte striatosulcata.*

3. *The Serpentinum-Beds* lie below the preceding, and consist of clays and layers of nodules of limestone, of much coarser texture than those of the "Fish and Insect Beds." *Harpoceras serpentinum, Harp. falciferum, Harp. Lythense, Harp. elegans,* and *Harp. radians,* are found in abundance with some Belemnites and other shells.

Professor Judd gives several sections of the Upper Lias, two of which I will quote as examples of the petrology of the series. On the left bank of the stream at Hallaton Ferns the junction of the Middle with the Upper Lias is well seen in a number of drain-fields. The succession of the beds here is as follows:

Upper Lias	1.	Dark blue clays.
	2.	Ferruginous beds, with *Harpoceras serpentinum* (abundant) and *Harpoceras bifrons.*
	3.	Paper-shales, with fish and insect limestone and usual fossils.
Middle Lias	4.	Sandy, ferruginous band, with moulds of shells. Marlstone rock-bed.
	5.	Light-coloured clays, with ironstone balls.

From a railway cutting near Market Harborough we have the following section:

	1.	Soil. 1 foot.
	2.	Boulder clay. 2 to 3 feet.
	3.	Upper Lias clay, with *Stephanoceras commune* and *Belemnites compressus.* It consists of laminated blue clay, weathering to a yellow colour. 1 to 4 feet seen in the pit.
Upper Lias: Serpentinum bed	4.	Hard, brown, ferruginous band of impure ironstone. 9 in.
	5.	Softer and more sandy bed, completely full of *Harpoceras serpentinum, Harp. bifrons, Stephanoceras commune, Steph. Holandrei, Belemnites compressus,* and other shells. 9 in.
	6.	Hard, very ferruginous bed. 3 ft. 6 in.
Middle Lias: Margaritatus bed	7.	Light-blue, laminated clays. 3 ft. 4 in.
	8.	A thin vein of sandstone, very inconstant. 1 ft.
	9.	Light-blue laminated clays. 5 ft.
	10.	Marlstone rock-bed of the Middle Lias. *Amaltheus margaritatus, Bel. paxillosus, Cardium truncatum, Avicula novemcostæ.*
	11.	Brown clay. 2 to 3 feet.
	12.	"Skerry," with nodules containing *Cardium truncatum, Avicula cygnipes, Lima* sp.
	13.	Brown clay. 2 to 6 feet.
	14.	Blue clay. 7 to 9 feet.
	15.	"Skerry" (brown sandstone). 1 to 6 feet.
	16.	Brown clay. 2 to 3 feet.
	17.	Rock, water-bearing stratum, further sinking prevented.

The fossils collected here show that the *Serpentinum*- and *Bifrons*-beds are those divisions of the Upper Lias which are best developed in Rutland, as the following list demonstrates:

CEPHALOPODA.

Harpoceras serpentinum, *Rein.*
— bifrons, *Brug.*
— elegans, *Sow.*
— falciferum, *Sow.*
— radians, *Rein.*
Stephanoceras commune, *Sow.*
Stephanoceras crassum, *Phil.*
— Holandrei, *d'Orb.*
— annulatum, *Sow.*
Phylloceras heterophyllum, *Sow.*
Belemnites compressus, *Voltz.*
— tenuis, *Phill.*

LAMELLIBRANCHIATA.

Leda ovum, *Sow.*
Inocramus dubius, *Sow.*
Ostrea subauricularis, *d'Orb.*
Posidonomya Bronni, *Voltz.*
Nucula cordata, *Goldf.*
Astarte striatosulcata, *Röm.*

From the above list it appears that the *Serpentinum*- and *Bifrons*-beds are so blended together in the Upper Lias of Rutlandshire that they have not yet been separated from each other, and that these two lower zones of the Upper Lias are the most persistent and widely developed of the upper division of the Lias formation in this County.

List of Fossils from the Zone of Harpoceras serpentinum (Gloucestershire).

REPTILIA.

Teleosaurus temporalis, *Blainv.*
Ichthyosaurus acutirostris, *Owen.*
Plesiosaurus (vertebræ).
Pterodactylus (coracoid of).

FISHES.

Pachycormus latirostris, *Agass.*
Leptolepis concentricus, *Egert.*
Tetragonolepis discus, *Egert.*
Dapedius, sp.

CRUSTACEA.

Coleia, sp.

INSECTA.

Libellula Brodiei, *Buck.*
Agrion Buckmanni, *Brod.*

CEPHALOPODA.

Belemnites tripartitus, *Sow.*
— Voltzii.
— subtenuis, *Phil.*
Nautilus astacoides, *Young and Bird.*
Stephanoceras commune, *Sow.*
— annulatum, *Sow.*
Harpoceras serpentinum, *Reinecke.*
Harpoceras bifrons, *Brug.*
— falciferum, *Sow.*
— Lythense, *Young and Bird.*
— Raquinianum, *d'Orbig.*
Lytoceras cornucopiæ, *Young and Bird.*
Phylloceras heterophyllum, *Sow.*
Belemnosepia (ink-bag and osselets).

GASTEROPODA.

Eucyclus capitaneus, *Münst.*
Trochus bisertus, *Phil.*
Cerithium, sp.
Pleurotomaria subdecorata, *Münst.*
Rostellaria, sp.
Natica, sp.

14. ZONE OF HARPOCERAS BIFRONS.

Synonyms.—"*A. communis*-bed," part, Wright, 'Quart. Journ. Geol. Soc.,' vol. xiv, p. 25, 1858. "Zone of *Am. communis*," part, Wright, 'Oolitic Asteroidea,' Palæont. Soc., p. 38, 1862. "Zone à *Am. bifrons*," Reynès, 'Géol. et Paléont. Aveyron,' p. 65, 1868. "*Leda-ovum*-beds," Judd, "Geol. of Rutland," 'Mem. Geol. Surv.,' p. 80, 1876. "Zone of *Am. communis* or *Alum-shale*," Tate and Blake, 'Yorkshire Lias,' p. 181, 1876.

This zone at Frocester Hill consists of fine sandy marls, with inconstant bands of a harder sand rock, which form several layers of nodules in the bank, and many of these contain fossils. I have found sometimes clusters of *Harpoceras bifrons* in some of these masses when broken up—a fact which first taught me the true stratigraphical position of *Harp. bifrons*. Along other escarpments of the Cotteswolds I have collected *Harp. bifrons* in brownish marl at the southern base of Crickley Hill, and in soft grey clays above the *Serpentinum*-bed at Stinchcombe Hill.

In the Saltwick profile near Whitby, and at Rock Cliff, near Staithes, on the Yorkshire coast, we have already seen that *Harp. bifrons* belongs to the alum-shale, and has for its associates *Stephan. commune*, *Belemnites Voltzii*, *Leda ovum*, and *Gresslya donaciformis*, and that it there forms a well-marked horizon of life resting upon the Jet-rock, with *Harpoceras serpentinum*, and *Harp. falciferum*.

On cutting the eastern portion of the Banbury and Cheltenham Direct Railway some instructive sections of the Upper Lias have been exposed on nearing Bloxam, Oxfordshire. Mr. Beesley[1] notes, "about 300 yards before reaching the Barford-road Bridge, a small fault brings down the Upper Lias about four feet against the *Spinatus*-beds. For 100 yards further the banks are all Marlstone of this zone; then comes another fault, dipping to the east, which throws down the Upper Lias to the base of the section, a depth of fifteen feet; the white marly limestone of the *Serpentinum*-beds, crowded with *Harpoceras bifrons*, *Stephanoceras commune*, *Lytoceras cornucopiæ*, *Phylloceras heterophyllum*, *Phyll. subcarinatum*, and species of the *Serpentinum* group, with *Belemnites Ilminsterensis* and *B. regularis* and *Nautili*, now forming the floor of the line, and over it blue or green shale fifteen feet thick. The faults pass obliquely across the line from north-west to south-east."

[1] "Geology of the Banbury and Cheltenham Railway," 'Proc. Geol. Assoc.,' vol. v, 1877.

Fossils from Bloxam Railway-Cutting.[1]

CEPHALOPODA.

Harpoceras bifrons, *Brug.*
— latescens, *Simp.*
— subplanatum, *Oppel.*
— Levisoni, *Simp.*
Stephanoceras commune, *Sow.*
— crassum, *Young.*
— Holandrei, *d'Orb.*
— fonticulum, *Simp.*
— gracile, *Simp.*
Lytoceras cornucopiæ, *Young & Bird.*
Phylloceras heterophyllum, *Sow.*
Phylloceras subcarinatum, *Young & Bird.*
Nautilus astacoides, *Young & Bird.*
— Jourdani, *Dumort.*
Belemnites Ilminsterensis.
— striolatus, *Phil.*
— pyramidalis, *Ziet.*
— quadricanaliculatus, *Quenst.*
— regularis, *Phil.*
— subaduncatus, *Voltz.*
— subtenuis, *Simp.*
— tripartitus, *Sehloth.*

GASTEROPODA.

Alaria angulata, *Moore.*
Cerithium, sp.
Chemnitzia Blainvillei, *Münst.*
Eucyclus capitaneus, *Münst.*
Natica Pelops, *d'Orb.*
Neritopsis transversa, *Moore.*
Pleurotomaria Joannis, *Dumort.*
— Theresæ, *Dumort.*
Purpurina armata, *Tate.*
Solarium, sp.
Actæonina, sp.
Trochus, sp.

LAMELLIBRANCHIATA.

Astarte subtetragona, *Goldf.*
Monotis inæquivalvis, *Sow.*
— Münsteri, *Goldf.*
— substriatus, *Münst.*
Cucullæa, sp.
Cypricardia Dumortieri, *Jaubert.*
Exogyra Berthandi, *Dumort.*
Hinnites tumidus, *Ziet.*
Inoceramus cinctus, *Goldfuss.*
— dubius, *Sow.*
— undulatus, *Ziet.*
Leda, sp.
Limea acuticosta, *Goldf.*
Lima Elea, *d'Orbig.*
— eucharis, *d'Orbig.*
— Galathea, *d'Orbig.*
— punctata, *Sow.*
Nucula cordata, *Goldf.*
— subglobosa, *Röm.*
Pecten pumilus, *Lamk.*
— textorius, *Schloth.*
Pholadomya Zieteni, *Agas.*
Pleuromya, sp.
Posidonomya Bronni, *Voltz.*
Plicatula catinus, *Deslong.*
Unicardium subglobosum, *Tate.*

BRACHIOPODA.

Discina reflexa, *Sow.*
Rhynchonella amalthei, *Quenst.*
— jurensis, *Quenst.*
— Moorei, *Dav.*
Waldheimia punctata, *Sow.*
— Lycetti, *Dav.*
Thecidium, sp.

[1] This list has been prepared and most kindly communicated to me at my request by Mr. Beesley, F.C.S., from his unpublished notes on the interesting and instructive section at the Bloxam Railway-Cutting, Oxfordshire; and for his courtesy I beg to record my best thanks.

Annelida.

Serpula gordialis, *Schlöth.*
— limax, *Goldf.*
— tricristata, *Goldf.*
Serpula ramentum, *Dumort.*
— segmentata, *Dumort.*
— lumbricalis, *Schloth.*

Echinodermata.

Rhabdocidaris impar, *Dumort.*
Cidaris Dumortieri, *Wright.*
Pentacrinus jurensis, *Quenst.*
Millericrinus Hausmanni, *Röm.*

Chondrites Bollensis, *Kurr.*

The fragments obtained from washing the bottom clay at Bloxam contained the remains of Ophiuridæ with the plates and spines of several species of Echinidæ.

Crustacea.

Bairdia, sp.
Cythere, sp.

Foraminifera.

Cristellaria Bronni, *Röm.*
— cultrata, *Montf.*
— antiquata, *d'Orb.*
— matutina, *d'Orb.*
— rhomboidea, *Czjek.*
— rotulata, *Lam.*
— recta, *d'Orb.*
— varians, *Born.*
Dentalina Burgundiæ, *Terq.*
— communis, *d'Orb.*
— filiformis, *d'Orb.*
— nummulina, *Gümb.*
Dentalina obscura, *Terq.*
— ornata, *Terq.*
— pauperata, *d'Orb.*
— quadricostata, *Terq.*
Flabellina rugosa, *d'Orb.*
Nodosaria raphanistrum, *Terq.*
— Badenensis, *d'Orb.*
Planularia harpula, *d'Orb.*
— pauperata, *J. & P.*
— reticulata, *Corneil.*
Lingulina tenera, *Born.*
Vaginulina striata, *d'Orb.*

In Rutland the *Serpentinum* and *Bifrons* zones approach so close together that their fossils in many cases cannot be separated. The *Serpentinum*-zone, with its "Fish-bed and Insect limestone," appears to be the one most fully developed in this county.

In North-West Lincolnshire the Rev. J. E. Cross, F.G.S.,[1] has noted the Upper Lias in the Santon Railway-cutting, and collected therefrom *Harpoceras serpentinum*, *Stephanoceras commune*, *Lytoceras cornucopiæ*, and *Amaltheus spinatus*.

Foreign Correlations.—The Upper Lias in South-west Germany was divided by Professor Quenstedt[2] into *Posidonienschiefer* and *Jurensis-Mergel;* the former corresponding to the *Serpentinum* and *Bifrons* zones, and the latter to the *Jurense* and *Opalinum* zones of this work. The "*Poisidonienschiefer*" are characterised by the presence of Fish, as *Ptycholepis Bollensis*, *Eugnathus*, *Tetragonolepis*, *Pholidotus semicinctus*, *Lepidotus Elvensis*, *semiserratus*, *dentatus*, *Semionotus leptocephalus*, *Aspidorynchus*, *Pachy-*

[1] 'Quart. Journ. Geol. Soc.,' vol. xxi, p. 124, 1875.
[2] 'Flözgebirge Würtembergs,' p. 539, 1843.

cormus, Thrissops, Leptolepis. Saurians, as *Ichthyosaurus, Plesiosaurus,* and *Teleosaurus.* Cephalopods, as *Harpoceras serpentinum, bifrons, Lythense, Phylloceras heterophyllum, Lytoceras cornucopiæ, Belemnites acuarius.* Lamellibranchs, as *Inoceramus dubius, Posidonia Bronni, Minotis substriatus, Leda ovum ;* and Brachiopods, as *Discina reflexa,* and others. The "*Jurensis-Mergel*" is characterised by the absence of Fish remains and the appearance of a new suite of Cephalopods, as *Lytoceras jurense, Harpoceras insigne, variabile, striatulum, radians, Aatense,* and many others.

At Pliensbach, north-west of Boll, and Holzmaden, south-west of Kirchheim, the following section by Dr. Oppel may be considered as typical of the Württemberg Upper Lias.

Upper Lias near Boll, Württemberg.

Torulosus-bed.

Petrology.		Thickness.	Organic Remains.
		ft. in.	
Zone of Lytoceras jurense	Two or three light grey, hard, marl beds, with clays ..... between 8 to	10 0	*Am. jurensis, discoides, insignis, radians, hircinus, Belemnites tricanaliculatus, exilis, longisulcatus, irregularis.*
Zone of Posidonomya Bronni	Efflorescent slaty shales, replaced in many places by the so-called "*Leberboden*"	8 0	*Am. bifrons, fibulatus, serpentinus, falcifer, heterophyllus, cornucopiæ, communis, crassus, Holandrei, subarmatus, Bel. irregularis, Bel. tripartitus.*
	Monotis bed	0 2	*Monotis substriatus,* Münst.
	Slaty beds, abounding with saurian and fishes' remains	0 2	*Belemnites acuarius.*
	Slaty beds with Teleosaurus, Pterodactyle, and fishes' remains	0 5	*Teleosaurus Chapmani, Pterodactylus Banthensis, Ptycholepis Bollensis.*
	Light-grey slaty clay.....	1 0	*Posidonomya, Bronni, Monotis substriatus.*
	Upper "*Stinkstein*".....	0 8	
	Slates with fishes and saurians	1 0	
	Hard laminated clay ... 2 to	0 4	
	Light efflorescent laminated slates	2 0	
	Lower "*Stinkstein,*" with fishes' remains	0 8	
	Laminated slates, with Geodes	5 0	*Leptolepis Elvensis.*
	"*Fleins*"	0 8	*Saurians, Pentacrinus Bollensis.*
	Hainzen pyritic nests	0 2	
	Bluish-grey clay, with Algæ		*Spiriferina villosus, Belemnites papillatus.*
	Blackish *Tafelfleins*	0 3–5	*Saurians* and *Sepiæ.*
	"*Algæschicht*"	1 6	*Acrosalenia crinifera, Quenst.*
The Middle Lias.—Zone of *Am. spinatus.*[2]			

[1] 'Juraformation,' p. 201, 1856.

Dr. Waggen states that the Upper Lias in Franconia closely resembles that of Swabia,[1] and that the zone of *Posidonomya Bronni* is very well developed there.

Professor Quenstedt[2] has given a good account of the palæontology of the Lias *Epsilon* at Boll, and has described in detail *Teleosaurus Chapmani*, König, *T. Bollensis*, Quenst., *Pelagosaurus*, sp. *Plesiosaurus Suevicus*, *Ichthyosaurus longirostris*, *Ichthyo. triscissus*, *Ichthyo. quadriscissi*, *Ichthyo. trigonodon*, and added the following list of fossils :

Palæontology of the Lias Upper "Epsilon" at Boll, Württemberg.

Fishes.

Hybodus pyramidalis, *Agass.*
— reticulatus, *Ag.*
Acrodus nobilis, *Ag.*
Lepidotus Elvensis, *Blainv.*
Dapedius cælatus, *Quenst.*
— punctatus, *Ag.*
— Leachii, *Ag.*
— pholidotus, *Ag.*
Tetragonolepis semicinctus, *Bronn.*
— cinctus, *Quenst.*
Ptycholepis Bollensis, *Agass.*
Pholidophorus Germanicus, *Quenst.*
Belonostomus acutus, *Agass.*
Pachycormus curtus, *Ag.*
— macropterus, *Ag.*
— Bollensis, *Quenst.*
Thrissops micropodius, *Ag.*
Leptolepis Bronnii, *Ag.*
Lycodus gigas, *Quenst.*
Pachylepis, sp.

Cephalopoda.

Loliginites Schubleri, *Quenst.*
— Bollensis, *Ziet.*
— simplex, *Voltz.*
— coriaceous, *Quenst.*
— sagittatus, *Münst.*
Onychoteuthis conocauda, *Quenst.*
Onychites uncus, *Quenst.*
— runcinatus, *Quenst.*
Belemnites acuarius, *Schlöth.*
— digitalis, *Quenst.*
— tripartitus, *Schlöth.*
Belemnites incurvatus, *Ziet.*
Ammonites Lythensis, *Young & Bird.*
— capellinus, *Quenst.*
— serpentinus, *Reinecke.*
— bifrons, *Brug.* = Walcotti, *Sow.*
— communis, *Sow.*
— crassus, *Phill.*
— Bollensis, *Quenst.*
— heterophyllus, *Sow.*
— cornucopiæ, *Sow.*
— anguinus, *Reinecke.*

Gasteropoda.

Chemnitzia repeliana, *d'Orb.*
Natica Pelops, *d'Orb.*
Turbo Sedgwicki, *d'Orb.*
Pleurotomaria subdecorata, *Münst.*
— intermedia, *Münst.*

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[1] 'Der Jura in Franken, Schwaben und der Schweiz,' p. 47, 1864.

[2] 'Der Jura,' p. 210, 1858.

Lamellibranchiata.

Ostrea subauricularis, *d'Orb.*
Pecten incrustatus, *Defrance.*
Gervillia Eseri, *Oppel.*
Avicula striata, *Ziet.*
Lima galatea, *d'Orb.*
Trigonia literata, *Phill.*
Leda ovum, *Sow.*
Goniomya rhombifera, *Goldf.*
Posidonomya Bronni, *Voltz.*
— radiata, *Goldf.*
— orbicularis, *Münst.*
Inoceramus undulatus, *Ziet.*
— cinctus, *Goldf.*
— dubius, *Sow.*
Solemya Voltzi, *Römer.*

Brachiopoda.

Discina papyracea, *Münst.*
Spiriferina villosa, *Quenst.*

Echinodermata

Acrosalenia crinifera, *Quenst.*
Pentacrinus Bollensis, *Schlöth.*
Pentacrinus fasciculosus, *Schlöth.*
— Quenstedi, *Oppel.*

In France the *Posidonomya*-beds attain a considerable development and are found in many Departments; they have been described in the Moselle by M. Terquem,[1] where they consist of (*a*) "*Marnes bitumineuses*," (*b*) "*Calcaire noduleux*," and (*c*) "*Calcaire gréseux*." The petrology of these divisions is certainly distinct, but several of the species of organic remains are common to the three, and all are characteristic of the lower portion of the Upper Lias.

In Luxembourg these beds have been described by Drs. Chapuis and Dewalque[2] as "*Marne de Grand-Cour*," which consists of a bituminous schist at the base and bluish marls with calcareous nodules in the upper part. The Marne de Grand-Cour has been worked at Aubange for the preparation of bitumen, and from these exposures the remains of Reptiles, Fishes, Crustacea, and Cephalopods have been collected. The following Ammonites from the lower zone have been figured by these authors:— *Harpoceras serpentinum, Harp. Lythense, Harp. complanatum, Phylloceras heterophyllum, Lytoceras cornucopiæ, Stephanoceras Raquinianum, Steph. Holandrei, Steph. mucronatum, Steph. Braunianum.* And from the upper zone: *Harp. radians, Harp. Levesquei, Harp. variabile, Harp. Comense.*

In the Department of the Ardennes it has been described by Buvignier as the upper marls of the Upper Lias; here, likewise, a bituminous schist forms the base, and marls the upper portion, of the series.

In the Meurthe M. Lavallois describes these strata as "*Marnes schisto-bitumineuses*."

[1] 'Paléontologie du Départ. de la Moselle, Ext. de Satist. de la Moselle,' p. 20, 1855.
[2] 'Lias de la Province de Luxembourg,' p. 60, 1857.

In the Yonne M. Cotteau[1] calls this series "*Lias supérieur masse argilo-bitumineuse.*" The following section, made at Vassy, from the summit of the hill to the plain which surrounds the town of Avallon, exhibits the sequence and relation of the Upper, Middle, and Lower Lias as developed in Yonne and described by M. Moreau, "Réunion extraordinaire à Avallon (Yonne) Soc. Géol. de France," 1845:[2]

First Stage: Upper Lias

1. Alternations of calcareous and marly beds with *Harpoceras bifrons*, Brug., *H. falciferum*, Sow., *Lytoceras cornucopiæ*, Sow., *Turbo ornatus*, Sow., *Posidonomya Bronni*, Voltz., *Nucula Hammeri*, Defr., *Thecocyathus mactra*, Edw.
2. Argillaceous schist and beds of argillaceous limestone from 0·01 m. to 0·02 m. thick alternate throughout this bed; the lower bed, of 0·40 m. to 0·80 m., is worked especially for the manufacture of the *Ciment de Vassy*. Veins of the carbonate of lime traverse all the mass of the hill, parallel with each other, and directed E. 40° N., like the soulèvement of the Côte-d'Or, inclining to the W., where they rise towards the ancient mass of Morvan. The fossils in these beds are common to No. 1 and 2.

Harpoceras serpentinum, Rein., *Phyll. heterophyllum*, Sow., *Stephanoceras annulatum*, *Stephan. commune*, *Stephan. Desplacei*, d'Orb., *Aptychus*, *Posidonomya Bronni*, Voltz., and the skull and jaws of *Ichthyosaurus*.

SecondStage: Middle Lias

3. Beds of limestone with *Gryphæa cymbium*, separated by thin beds of calcariferous clay. Belemnites are very abundant, with *Amaltheus margaritatus*, Mont., *Lytoceras fimbriatum*, Sow., *Pecten æquivalvis*, Sow., *Terebratula quadrifida*, Sow., *T. ringens*, Sow., *Rhyn. tetraedra*, Sow., *Rhyn. variabilis*, Schlöth., *Spiriferina Walcotti*.
4. Argillaceous marls, without fossils, with Septaria.
5. Limestone very argillaceous, with *Belemnites clavatus*, Blain., *Bel. umbilicatus*, Blain., *Bel. Bruguierianus*, d'Orb., *Terebratula numismalis*, Lam., *Rhyn. rimosa*, *Spiriferina Walcotti*, Sow., *Aegoceras Davœi*, Sow., *Aeg. Henleyi*, Sow., *Aeg. hybrida*, d'Orb.

Third stage: Lower Lias

6. Limestones with *Gryphæa arcuata*, Lam., divisible into two beds.
   - *a*. Upper bed with *Gryphæa arcuata*, Lam., *Arietites Bucklandi*, Sow. = *bisulcatus*, Brug., *Rhyn. variabilis*, Schloth.
   - *b*. Lower bed with *Gryphæa arcuata*, Lam., *Gryph. Maccullochii*, Sow., *Arietites bisulcatus*, *Arietites Coneybeari*, Sow., *Spiriferina Walcotti*, and *Pentacrinus basaltiformis*, Mill.

In the Côte d'Or a similar condition of the *Posidonomya*-beds prevails at Flavigny, where M. Collenot says[3] an exposure by erosion shows—First, the zone with *Harp. serpentinum* resting upon schists containing *Gryphæa cymbium*, and consisting of their paper-like shales without bitumen. Here are found, also, *Stephanoceras Holandrei*, *Phylloceras heterophyllum*, rarely *Harpoceras bifrons*. Second zone with *Harpoceras complanatum*. The rock is less bituminous and more aluminous than the preceding, and the fossils are large and widely distributed throughout the beds. The third zone is characterised by *Pecten pumilus* and *Turbo subduplicatus*, which is limited to this one

[1] 'Études sur les Échinides Foss. de Départ. de l'Yonne,' p. 32, 1849.
[2] 'Bulletin de la Soc. Géol. de France,' 2e série, tom. ii, p. 664, 1843.
[3] 'Description Géologique de l'Auxois,' p. 288, 1873.

horizon with *Hellispongia fasciculata*. The fourth zone, composed of compact marls with few fossils, is characterised by the presence of *Steph. mucronatum*.

In the Isère at Verpillière and St. Quentin the *Posidonomya*-beds are formed of ferruginous layers with very fine fossil shells in a high state of preservation; and the relation of the *Posidonomya* to the *Jurense*-zone is likewise very well displayed. The following species are characteristic of the *Posidonomya*-beds at Verpillière:

Belemnites acuarius, *Schlöth.*
Harpoceras bifrons, *Brug.*
Lytoceras cornucopiæ, *Young & Bird.*
Stephanoceras annulatum, *Sow.*
— commune, *Sow.*
Stephanoceras Holandrei, *d'Orb.*
— crassum, *Phil.*
— fibulatum, *Sow.*
— subarmatum, *Sow.*
— anguinum, *Rein.*

In the Loère and the Aveyron the Upper Lias is well developed, and both the *Posidonomya*- and *Jurense*-beds are here found in natural superposition. The late Dr. Reynès,[1] after carefully studying these beds in the Aveyronnaise, divided them into four zones, and observed that the faunas have very little affinity with each other,—"we only ascertain but very rarely the appearance of a species beyond the zone in which it has taken its entire development, and it is still more rare that we see isolated examples ever appearing in beds of a later horizon." To facilitate the stratigraphical and palæontological study of the Upper Lias this author divided the Upper Lias into four parts:—1. The zone of *Harp. serpentinum*; 2, the zone of *Harp. bifrons*; 3, the zone of *Lyto. jurense*; and 4, the zone of *Harp. opalinum*.

1. The schists with *Posidonia Bronni* are from 3 to 30 mètres in thickness; they split into thin laminæ, on which are impressed the marks of fossils, as *Aptychus Lythensis*, *Harp. serpentinum*, *Posidonia Bronni*, and others. The shells are so much compressed that it is difficult to restore their former character; fortunately, however, these laminated shales contain many large, hard, calcareous, fossiliferous nodules, which contain uncrushed shells in good preservation. On breaking up the nodules the following species were collected:

Harpoceras serpentinum, *Rein.*
— Levisoni, *Simp.*
Stephanoceras commune, *Sow.*
Aptychus Lythensis.
Posidonia Bronni, *Voltz.*
Anodonta Bollensis, *Quenst.*

"The fauna is not numerous, and none of the species of this list ascend into the zone of *Harp. bifrons*. It is true that some palæontologists have considered *Harp. Levisoni* as the prototype of *Harp. bifrons*. In this case they are under the necessity of recognising two distinct varieties, the one having a lateral groove, and the other deprived of that canal; they are also forced to admit that these two varieties have lived at two distinct epochs and without any intermixture, and that this modification is made in a sudden manner with the appearance of the fauna of *Harp. bifrons*. These diverse

[1] 'Essai de Géologie et de Paléontologie Aveyronnaises,' p. 63, 1868.

considerations have led me to regard the supposed varieties as distinct species, whatever may be the affinities or the minglings they have had in common in other countries."

2. The zone of *Harp. bifrons.* "This zone is marly, and the change which has taken place permits us to assign to it a precise lower limit. But it is not so easy to find the upper boundary, and it is even necessary to make the palæontological characters intervene; but we often meet at the base of the zone following with *Lyto. jurense*, a bed of *Tissoa*—the compressed condition of which gives it the aspect of a true limestone. It is this bed, the thickness of which is 10—15 centimètres, entirely enclosed in the marls of the two zones, which appears to form the upper limit of the zone of *Harp. bifrons;* it is, in fact, above and below this bed that we observe a considerable change in the two faunas. The marls are black and entirely argillaceous; and enclose a large number of species, of which the representatives are distributed according to fixed laws in different levels of that zone."

"*a.* At the base we find *Stephan. Braunianum.* It is in this horizon that we discover that fauna so curious and so new, and which is enclosed in a marly bed immediately in contact with the *Posidonia*-shales. The marls in which this fauna is enclosed do not exceed a mètre and a half in thickness, and the principal species found here are:

Stephanoceras Braunianum, *d'Orb.*
— crassum, *Phill.*
— Zitteli, *Oppel.*
Phylloceras subcarinatum, *Sow.*
Lytoceras Nilssoni, *Hebert.*
— cornucopiæ, *Sow.*
Lytoceras Argelliezi, *Rey.*
Aegoceras acanthopse, *d'Orb.*
Harpoceras falciferum, *Sow.*
Nucula Paulæ.
Cerithium hexagonum.
Rhynchonella Julii.

"*b.* In the middle zone we recognise the true station of *Harp. bifrons*, and the fossils are very numerous.

Belemnites irregularis, *Schlöth.*
— acuarius, *Schlöth.*
— tripartitus, *Schlöth.*
Nautilus semistriatus, *d'Orb.*
Harpoceras falciferum, *Sow.*
— bicarinatum, *Münst.*
— bifrons, *Brug.*
Lytoceras Nilssoni, *Hebert.*
Stephanoceras crassum, *Phil.*
— subarmatum, *Young.*
— Emilianum, *Rey.*
Aegoceras Gervaisi, *Rey.*
Harpoceras Erbaense, *Hauer.*
Plicatula Neptuni.
Lima gigantea.
— pectinoides.
Pecten incrustatus.
Arca Bixa.
Nucula ovum.
— Delila.
Avicula Delia.

"*c.* The upper part of this zone no longer includes *Harpoceras bifrons*, and we only meet in this horizon with *Lytoceras Nilssoni, Harp. bicarinatum, Harpoceras falciferum, Harp. Erbaense, Stephanoceras subarmatum*, and *Phylloceras heterophyllum.*

"This remarkable distribution of the species, according to distinct horizons, is almost general, with rare exceptions, and we are able to assign beforehand to each species the

position which it ought to occupy in the extent of the marls of the Lias. The same species are not equally abundant in all localities; and this proves to us that the species of former times, like those of the present day, did not frequent indiscriminately such and such regions."[1]

In Normandy the lower zones of the Upper Lias have been studied with great care by Professor Deslongchamps, and many of the remarkable fossils they contain have been figured and described in his interesting '*Mémoire sur la Couche à Leptæna du Lias*,' already referred to, p. 119, in correlation with similar beds in the Upper Lias of Gloucestershire and Somersetshire. The quarries of Curcy, d'Évrecy, May, &c., near Caen, are good localities for the study of this zone, and the following section at Curcy affords a clear exposure of the Upper and Middle Lias in natural position there.

Section at Curcy, Calvados.

Upper Lias.

No.	Petrology.	Thickness.	Organic Remains.
		mètres.	
1	A very ferruginous, yellowish or reddish clay, containing rolled Oolitic blocks and fossils	?	The fossils belong to the Oolitic beds, and resemble a like deposit of Drift at Moutiers.
2	Alternate beds of limestone and thin bands of clay, containing many fossils	?	*Harp. serpentinum, Harp. bifrons, Stephan. Holandrei.*
3	Thick masses of very tenacious, greyish, yellowish or blackish clay, with a band of calcareous nodules containing Fishes	7 to 8	*Posidonomya Bronni, Geotheutis Agassizii, Aptychus.*
4	"*Couche à Leptæna*," a very thin bed of reddish marl, formed of the fragments of various fossils, and a singular assemblage of organic remains ...	1 to 2 decimètres	*Ter. globulina, Rhyn, pygmæa, Leptæna Moorei, Lep. liasiana, Lep. Davidsoni, Lep. Bouchardi, Thecidea Mayalis, sinuata, rustica, Eugeniacrinus, Plicatocrinus, Cotylederma,* spines and plates of *Echinidæ.*
	Middle Lias.		
5	"*The Roc*," a sandy saccharoid limestone, containing many fossils, and forming a good horizon	mètres. 1 to 2	*Am. spinatus, Am. margaritatus, Lyt. fimbriatum, Belem. niger, Gryphæa cymbium, Spiriferina rostrata, Tevebratula quadrifida.*
6	Alternate beds of marl and limestone, of variable thickness, and containing many fossils	?	*Rhyn. tetraedra, Rhyn. acuta, Gryphæa cymbium, Harpax Parkinsoni, Terebratula numismalis, Rhyn. variabilis, Spiriferina verrucosa, Spirif. rostrata.*

[1] Ibid., p. 66.

[2] 'Bulletin de la Société Linnéene de Normandie,' vol. iii, 1859.

The following typical section of the Upper Lias, "*l'étage Toarcien*," was made by Professor Alcide d'Orbigny at Thouars, Deux-Sèvres,[1] where the daily working of the beds exposes beautiful natural profiles. The relation of the *Jurense* and *Serpentinum* zones are here likewise well seen *in situ*.

Section of the "Toarcian" at Thouars, Deux-Sèvres.

No.	Petrology.	Thickness.	Organic Remains.
1	Thick bed of very white argillaceous limestone, containing flint	?	*Belemnites tripartitus.*
2	Limestone and argillaceous clay.....	?	*Lytoceras jurense.*
3	Alternate beds of bluish clay and limestones, passing at the upper part into a ferruginous clay	?	*Harpoceras insigne, Harpoceras radians, Belemnites irregularis.*
4	Blue clay	?	*Harpoceras variabile, Belemnites tripartitus.*
5	Grey granular limestone...	?	*Harpoceras Thouarsene.*
6	Compact limestone	?	Non-fossiliferous.
7	Thin beds of ferruginous clay		*Harpoceras serpentinum.*
8	Thick bed of sandy limestone, raised for building-material.....	?	
9	Bed of foliated saccharoid limestone ...	?	
10	Thick bed of yellow limestone, with some grains of quartz, the lowest bed of l'étage Toarcien	?	

15. The Zone of Lytoceras Jurense.

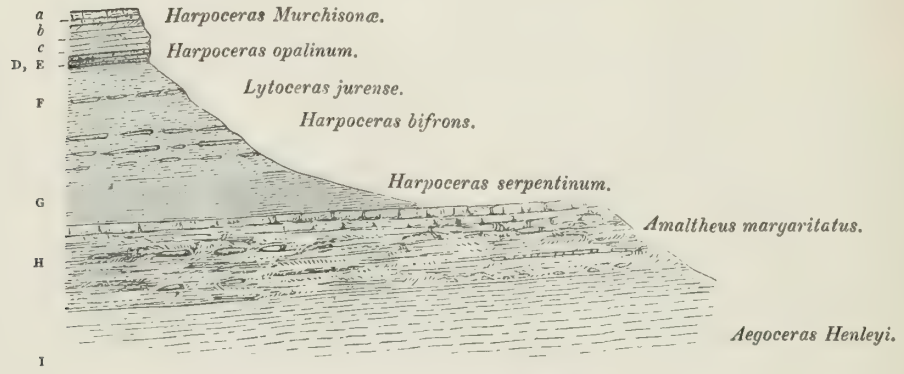
Synonyms.—"Sands of the Inferior Oolite," Smith, De la Beche, Conybeare, and other English authors. "Jurensismergel.," Quenst., 'Flözgeb. Würtemberg,' p. 599, 1843. "9e étage Toarcien (pars sup.)," d'Orbigny, 'Cours élément. de Paléontologie,' p. 469, 1852 (sect. at Thouars *h* to *l*). "Zone des *Amm. torulosus* und Zone des *Amm. Jurensis*," Oppel, 'Juraformation,' p. 296, 1856. "Cephalopoda-bed and Upper-Lias Sands," Wright, 'Quart. Jour. Geol. Soc.,' vol. xii, p. 292, 1856. "Marnes d'Aresche, et Marnes de Pinperdu, Jura franc-comtois," Marcou, 'Les Roches du Jura,' p. 119, 1857. "Ammonite Sands," Hull, 'Mem. of the Geol. Surv., Country around Cheltenham,' p. 25, 1857. "Cynocephala stage," Lycett, 'Cotteswold Hills,' p. 16, 1857, "Jurensis bed," Wright, 'Quart. Jour. Geol. Soc.,' vol. xiv, p. 25, 1857. "Lias Zeta," Quenstedt, 'Der Jura Uebersichtafel,' p. 293, 1858. "Zone of *Am. Jurensis*," Wright, 'Oolitic Asteroida, Pal. Soc.' Vol. 1862. "Midford Sands," Phillips, 'Geol. of Oxford and the Valley of the Thames,' p. 118, 1871.

This younger member of the great Lias formation is well developed in the counties

[1] 'Cours Élément. Paléontologie,' tom. ii, p. 469.

of Gloucester, Somerset, Dorset, and at Blue Wick, or Blea-Wyke, near Robin Hood's Bay, on the Yorkshire coast. It may be most advantageously studied in the fine section at Frocester Hill, and in other smaller exposures in the Nailsworth and Brimscombe Valleys in Gloucestershire. The following section of Frocester Hill, near Stonehouse, affords one of the best types of the zone of *Lytoceras Jurense* in the county of Gloucester.

Fig. 8.—*Section of Frocester Hill, near Stonehouse.*



a, *b*, *c*. Inferior Oolite; 70 feet. Zone of *Harpoceras Murchisonæ*.

D, E. Calcareo-ferruginous sandstone (Cephalopoda bed); 6 feet. { Zones of *Harpoceras opalinum* and *Lytoceras jurense*.

F. Grey, yellow, and brown sands, with inconstant, concretionary bands of calcareous sandstone; 150 feet? Zone of *Harpoceras bifrons*.

G. Upper Lias shale; 80 feet. Zone of *Harpoceras serpentinum*.

H. Marlstone; hard calcareous sandstone, resting on brown and grey sands, with bands and nodules of ferruginous sandstone; 150 feet. Zone of *Amaltheus margaritatus*.

I. Middle Lias shale. Zone of *Aegoceras Henleyi*.

In very few localities, where the sands are exposed along the escarpments of the Cotteswolds or in the beautiful valleys intersecting these hills, are they found to contain organic remains; but fossiliferous seams have, however, been discovered at Frocester, Brimscombe, Nailsworth, Uley Bury, North Nibley, and Ozleworth, and doubtless will be detected in other localities in this neighbourhood when the strata are exposed.

The fossiliferous bed at Nailsworth lies near the base of the sands 4 or 5 feet above the Upper Lias clay, and consists of a fine soft ferruginous marly sandstone, of a rich brown colour, containing much peroxide of iron, with many shells, mostly of the same species found in the Cephalopoda-bed at Frocester. The difference between these two beds is important, and deserves to be noted, as the Cephalopoda-bed at Frocester overlies the sands, whilst the fossiliferous bed at Nailsworth underlies them near their base, clearly proving that the sands and Cephalopoda-bed form one stage.

In Somersetshire the *Jurense*-zone is met with in several sections south of the Mendips, resting upon the *Crania*-clays of the Upper Lias, as in the section at Straw-

berry Bank, Ilminster, already described at p. 119; where the rock consists of alternate strata of clay and stone, in which are found *Harpoceras insigne*, *Harpoceras variabile*, and *H. opalinum*, var. *Moorei*. These Ammonites have not migrated, as some geologists state, from the Upper Lias sea into the Cephalopoda-bed of the sands above, inasmuch as neither of the species are ever found in the *Serpentinum* and *Bifrons* zones, but are truly characteristic forms of the *Jurense*-zone, of which they form the leading species.

South of the Mendips the sands attain a thickness of 160 feet, whilst north of that range they diminish much, are extremely variable, and are absent in several localities. Near Bath they are about 40 feet thick, and are well exposed in the railway tunnel under Combe Down; also at Midford, near the late Dr. William Smith's house, hence the origin of the name, "Midford Sands."

In Dorsetshire this zone is found in several localities. I have carefully examined it in the following; at Chideock Hill, between Bridport and Charmouth, it is exposed near the summit, and consists of a very fine sandy rock of a light yellow colour, sometimes micaceous, in which I found good specimens of the following Ammonites, *Harpoceras insigne*, *Harp. variabile*, and *Harp. opalinum*, all characteristic species in good preservation. From Burton Bradstock I have obtained some large *Harp. opalinum* and *Harp. variabile* in a fine yellow sandy matrix; the sands here attain a considerable thickness, and have several inconstant bands of sandstone intersecting the deposit. At the east side of Bridport Harbour there is a magnificent coast section of the sands, estimated at upwards of 200 feet in thickness; and between Bridport Harbour and Burton Bradstock there are several good quarry sections, which show the upper rag-stones of the Inferior Oolite resting upon the Cephalopoda-bed. These two rocks so closely resemble each other in their petrology, that, but for the organic remains they contain, it would be impossible to separate them. Fortunately, however, the Inferior Oolite contains many Ammonites, Bivalve shells, Echinides, and Corals, which are typical of the Lower Oolitic beds, so that the divisional line between them can be surely drawn by palæontological evidence where lithology fails to do so. At the west side a fault has depressed the sands, which are here overlain by thin beds of Inferior Oolite and Fuller's Earth. Near Yeovil several instructive sections of the sands are exposed in the railway-cuttings around that town, and in the neighbourhood of Sherborne the sands are about 140 feet thick.

My friend Dr. Lycett, in his notes on the Ammonites of the sands intermediate to the Upper Lias and Inferior Oolite, intending to afford a concise analytic examination of their natural-history, characters, and geological distribution, assumed that it had been generally considered that all the species belonged to the lower horizons of the Upper Lias, but this was not the teaching of my Memoir, in which, by many sections and carefully prepared lists of the palæontology of the Upper-Lias sands[1] in the counties of

[1] "Notes on the Ammonites of the Sands intermediate to the Upper Lias and Inferior Oolite," 'Trans. Cotteswold Naturalists' Club,' p. 3, 1862.

Gloucester, Somerset, Dorset, and York, the Cephalopoda-bed and its underlying sands were shown to represent a well-marked horizon with specific forms of Ammonoida that were found neither in the Alum-shale or *Bifrons*-bed below, nor in the Inferior Oolite or *Murchisonæ*-zone above, and certainly represented a horizon of life, the correlative of the *Jurensis-Mergel* of Quenstedt.

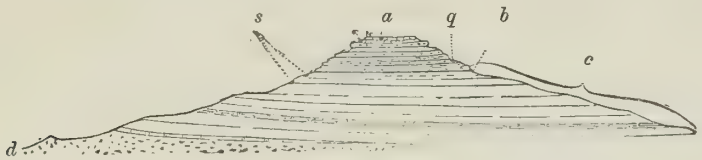
The late Professor John Phillips[1] proposed the name "Midford Sands" for "the last of the Liassic strata to which the Inferior Oolite had not quite relinquished its ancient claim. . . . . They are covered in many districts of the south of England by calcareous and shelly beds, which on first view appear naturally associated with the Oolitic rocks above; but they contain many fossils which are frequent in the Sands and not common in the Oolites. . . . . If we wish to draw a hard limit of mineral deposits it should probably be between the sand and its calcareous cover (which is often absent), but if we desire to study organic sequence we shall unite the sands and their shelly cap into a transition group. In this point of view the facts which have come out by inquiry are very instructive. Taking first the group Cephalopoda, we find some of the well-known species of the Upper Lias to be continued through the sands into the shelly bed above, as *Ammonites bifrons, A. opalinus, A. striatulus, A. concavus, Belemnites compressus, B. irregularis, B. tripartitus.* On the other hand several Conchiferous Molluscs, which occur with these Cephalopoda, have decided Oolitic and not Liassic affinity. Such are *Hinnites abjectus, Trigonia striata, Modiola Sowerbii, Pholadomya fidicula.* Before the Liassic life has come to an end the Oolitic life has begun; a point of great importance in the reasoning on the causes of successive variation in the oceanic population, and one which will come before us again on several occasions while following the course of Oolitic time. The Cephalopoda-bed . . . . is not known in the valleys of the Cherwell or Evenlode, and very partially in any of the branches of the Windrush, Coln, or Churn. But on the western front of the Cotteswold cliffs it extends from Cleeve-Cloud to Wotton-under-Edge, appears on the Dorsetshire coast, near Bridport, and is recognised in France."

In the palæontological table which accompanies this section it will be shown that *Harp. striatulum* and *Harp. opalinum* are not found in the Upper Lias properly so called, but appertain to the *Jurense*-bed, and that *Harp. bifrons* is a leading fossil of the clay bed of the Upper Lias, but is not found in the *Jurense*-zone unless as a fossil washed out of an older bed and redeposited in a newer formation.

Dundry Hill, near Bristol, 769 feet in altitude above sea-level, is the most westerly outlier of the Cotteswold range, from which it is nine miles distant; this is a locality of great interest to the naturalist, as it affords capital sections of the Jurassic strata, admirable examples of rock-sculpture by denudation, and a commanding point for surveying the grand panorama in the midst of which it stands. The following profiles of this hill show its structure very clearly.

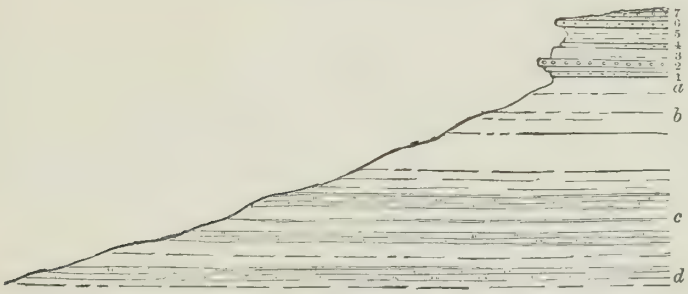
[1] 'Geology of Oxford and the Valley of the Thames,' p. 118, 1871.

Fig. 9.—*Section across Dundry Hill, showing its cap of Inferior Oolite.*



a. Inferior Oolite.
b. Upper Lias.
c. Middle and Lower Lias.
d. New Red Sandstone.
q. Quarries of Oolitic Limestones.
s. Origin of the springs of water.

Fig. 10.—*Lateral profile of Dundry Hill.*



7.	Freestone Building Oolite,	12 feet.	1.	Ironshot Pleurotomaria Bed,	2 feet.
6.	Fine-grained Oolite	4 „	*a*.	Upper Lias Sands	2–3 „
5.	Shelly Ragstones	8 „	*b*.	Upper Lias Clay	4 „
4 & 3.	Rubbly Shelly Limestones,	12 „	*c*.	Middle Lias	1 „
2.	Zone of *Harp. Sowerbii*	3 „	*d*.	Lower Lias	369 „

The Oolitic rocks exposed at the summit of the hill belong to the Inferior Oolite, which, in the south of England, admits of a division into three zones of life. The lower resting upon the Upper-Lias Sands has *Harpoceras Murchisonæ* as its leading fossil; the middle contains a large assemblage of Mollusca, among which the Ammonoida predominate, and these chiefly belong to *Stephanoceras Humphriesianum*, *Steph. Brongniarti*, and *Steph. Brocchii*; the upper zone is characterised by *Cosmoceras Parkinsoni*, *Perisphinctes Martinsii*, and *Oppelia subradiata*, with many Echinidæ and a large series of reef-building Corals. These three subdivisions are rarely all found together in the same locality, but the order of their sequence in nature is, as stated, in Dundry.

1. In the ironshot shelly beds are many Lamellibranch Molluscs and a rich assemblage of Pleurotomarias. These are covered by the second Ammonite-zone with *Stephanoceras Humphriesianum*. Many of these are beautifully preserved Ammonoida with the shell entire, the mouth-processes developed, and the *Aptychi in situ*, as *Stephan. Humphriesianum*, *Steph. Brocchii*, *Steph. Brongniarti*, *Steph. Blagdeni*, *Steph. Gervillei*, and others. The Conchifera beds 3 and 4 contain *Harpoceras Sowerbii* and a large assemblage of Lamellibranchs with Echinidæ and Anthozoa belonging to the middle

beds of the Inferior Oolite. The Ragstones rest on them, and here appear for the first time small *Cosmoceras Parkinsoni*, *Pleurotomaria proteus*, *Pholadomya Heraulti*, *P. ovulum*, *Ceromya Bajociana*, *Terebratula perovalis*, *Ter. spheroidalis*, *Ter. globata*, *Rhynchonella spinosa*, *Rhyn. plicatella*, with Echinoderms, as *Magnotia Forbesii*, *Stomechinus intermedius*, *Echinobrissus clunicularis*, and *Holectypus depressus*, all forms of Echinidæ found for the first time in the *Parkinsoni*-beds.

The fine-grained oolite or building-stone, No. 6, resting upon the preceding, which much resembles Portland stone, is extensively raised as a valuable building material.

The coarse oolite or Freestone beds are the highest set of strata observable at Dundry Hill. Shells are not common in these rocks, but several Corals are here located, as *Isastræa explanata*, *Stylina solida*, *Thamnastræa Defranciana*, *Latomæandra Flemingii*, *Isastræa tenuistriata*, with Crinoids as *Pentacrinus Milleri*.

The Oolitic rocks rest upon the Upper-Lias Sands, *a*, or zone of *Lytoceras jurense*, which is seen at the western side of the hill. The sands are only from 2 to 3 feet in thickness, and contain dwarfed specimens of *Modiola plicata*, *Pholadomya fidicula*, *Lima bellula*, *Belemnites irregularis*, *Bel. compressus*, and small *Harp. insigne*, so that this arenaceous deposit, which attained 80 feet in thickness at Frocester and 125 feet at Wootton-under-Edge, has almost disappeared at Dundry.

The zone of *Harpoceras bifrons* is feebly developed at Dundry, only a few small, dwarfed specimens of *Harp. bifrons*, *Stephan. commune*, *Belemnites tripartitus*, with a *Pholadomya*, and a *Modiola*, have been found in these Upper Lias clays.[1]

The Middle Lias is here feebly represented, and in this respect presents a remarkable contrast to the great development this division attains in the escarpments of the Cotteswold Hills, and in the country around Bath.

The Lower Lias in the Dundry district is well seen at Bedminster Down, Keynsham, Whitchurch, Queen Charlton, Norton Malreward, Winford, and Barrow; in ascending from all these localities to the summit of the Hill we pass in succession from the Red Marl at Bedminster, over the *Avicula contorta*, *Planorbis*, *Bucklandi*, *Turneri*, and *Obtusus*-beds, which have a collective thickness of 450 feet.

I beg to refer the student to the section of the *Bucklandi*-beds at Saltford, near Bath, pp. 36 and 37, and of the *Planorbis*, and *Avicula-contorta*-beds in the same cutting, as affording all the details of these strata yet known on the subject in this district.

Those readers who may be interested in the Palæontology of the Dundry district will find in the 'Proceedings of the Bristol Naturalists' Society,' vol. i, p. 9, new series, 1874, a most valuable memoir by Mr. E. B. Tawney, F.G.S., entitled "Museum Notes—Dundry Gasteropoda." This paper contains a list of sixty-four species, many of which are beautifully figured for the first time, and the whole are most minutely and accurately described. It is an important addition to British Jurassic palæontology.

[1] For full details on the Dundry Hill section, I beg to refer to my friend Mr. R. Etheridge, F.R.S., notes on Dundry Hill, in my Memoir on the "Subdivisions of the Inferior Oolite," 'Quart. Journ. Geol. Soc.,' p. 21, vol. xvi, 1860.

Whilst this sheet was passing through the press my esteemed friend Mr. W. W. Stoddart, F.G.S., of Bristol, kindly sent me a detailed section of Dundry Hill, measured by himself, with the vertical thickness and barometrical height of the chief beds in the section in feet. This I have endeavoured to embody in the form adopted in this work; and I thank my friend for the same.

Section of Dundry Hill. Dip 20° N.N.E.

Period.	Zone.	No.	Strata.	Vertical Thickness. ft.	in.	Barometrical Height. ft.
Inferior Oolite	Parkinsoni about 23 feet	1	Freestone	16	9	769
		2	Ragstone	6	0	
	Humphriesianum about 20 feet	3	Coral	1	0	
		4	Echinus	1	6	
		5	Brachiopoda	4	8	
		6	Conchifera	8	0	
		7	Cephalopoda	3	0	
		8	Ironshot	2	0	614
Lias	Jurense about 2 feet	9	Midford Sands	2	0	
	Bifrons 4 feet	10	Upper Lias	4	0	
	Henleyi 1 foot	11	Middle Lias	1	0	523
	Obtusus about 80 feet	12	Limestone and Marls	80	0	
	Turneri about 26 feet	13	Limestones and Marls	24	0	
		14	Limestone	2	3	367
	Bucklandi about 120 feet	15	Limestones and Marls	120	0	
	Planorbis about 143 feet	16	Limestones and Marls	143	0	
Rhætic	Avicula contorta about 65 feet	17	Argillaceous Limestones and Clays	65	0	150
Trias	Keuper about 78 feet	18	Variegated Marls			

It is now twenty years ago since I discovered the *Jurense*-zone at Blue Wick, near Robin Hood's Bay, on the Yorkshire coast,[1] beneath a rock which I considered the equivalent of the basement bed of the Dogger or Inferior Oolite. It was a yellowish sandstone, containing several seams of small round pebbles, which lie near the bottom. The pebbly conglomerate is about 4 inches in thickness, and occurs at intervals. The sandstone contains fragments of Belemnites, *Cerithia*, and *Monotis nitescens*, Simp. The bed is about 5 feet thick, and lies on No. 1, a band of dark friable shale, resting on a hard ironstone band full of fossils. This bed is very micaceous in parts, and many of the shells are stained with ferric oxide. I found *Terebratula trilineata*, Young and Bird, in clusters in the sandstone, with *Belemnites compressus*, Voltz, *Bel. irregularis*, Schloth., *Trigonia Ramsayi*, Wright, and *Rhynchonella cynocephala*, Rich. These species occur also in a ferruginous seam of sandstone at Glaizedale. This bed is 18 inches thick, and rests on No. 2, the *Yellow Sandstone*, which is well exposed at Blue Wick. It consists of irregular layers of soft yellow sandstone, unequally indurated; some portions weather out and leave hollows in the cliff, whilst others are fine-grained, yellowish, highly micaceous, thick-bedded, and variously jointed. The upper part of this rock is ochraceous, and contains fossiliferous seams. Here I found in one large block *Harpoceras Comense*, von Buch, *Harp. insigne*, Schübl., *Goniomya angulifera*, Sow., *Monotis inæquivalvis*, Sow., *Trigonia Ramsayi*, *Cerithium* sp., *Turritella* sp., *Astarte* sp., *Gresslya pinguis*, *Glyphæa Birdii*, Bean. This bed is about 20 feet in thickness.

No 3, the *Serpula*-bed, a fine-grained greyish-yellow sandstone, which forms a reef, dips gently to the south-east, and presents a low escarpment to the north; it is regularly jointed, and the exposed upper surface contains masses of *Serpula diplexa*, Bean, *Vermetus compressus*, Will., *Pecten intercostatus*, Wright, *Harpoceras Aalense*, Ziet. (var. *Moorei*, Lyc.), and *Heterocidaris Wickensis*, Wright. This bed is 10 feet in thickness; the upper 4 feet are most fossiliferous; in the lower six feet the same species of shells are sparsely distributed.

No. 4, the *Lingula*-bed or grey sandstone is a soft argillo-micaceous sandstone of a bluish-grey colour, and partly fissile. This rock is divided by long joints, and forms "scars" at Blue Wick. Its upper, fissile portion is fossiliferous, and contains *Lingula Beanii*, Phil., *Discina reflexa*, Sow., and *Monotis nitescens*, Simp. About the middle of the bed a layer of small nodules occurs, fragments of Crustacea, *Glyphæa Birdii*, Bean, and *Glyphæa*, n. sp., allied to *rostrata*, are found in these nodules. The lower portion is rough and sandy, and passes into hard, argillaceous, nodular layers: I collected the following species from the sand:

Harpoceras Aalense, *Ziet.*
— variabile, *d'Orb.*
Belemnites compressus, *Voltz.*
— irregularis, *Schloth.*
Alaria Leckenbi, n. sp., *Wright.*
Cerithium quinque-punctatum, *Deslong.*
— vetustum, *Phil.*
Mytilus Wickensis, *Wright.*

[1] 'Quart. Journ. Geol. Soc.,' vol. xvi, pp. 3 and 4.

Pecten Wickensis, *Wright.*
Goniomya angulifera, *Sow.*
Pholadomya fidicula, *Sow.*
— obliquata, *Phil.*
Monotis substriata, *Münst.*
Gresslya peregrina, *Phil.*
Gervillia Hartmanni, *Goldf.*
Pinna cuneata, *Bean.*
Cucullæa cancellata, *Phil.*
Lingula Beanii, *Phil.*
Rhynchonella cynocephala, *Rich.*
Discina reflexa, *Sow.*
Terebratula trilineata, *Young & Bird.*
Glyphæa Birdii, *Bean.*
— n. sp. allied to G. rostrata.
Heterocidaris Wickensis, *Wright.*

No. 5, hard argillaceous shales with layers of nodules, which lie at the base of the sand, and rest upon the Alum-shale. In this band, however, are found certain species of Ammonoida not met with in any other rock on the Yorkshire Coast, and they are all leading fossils of the zone of *Lytoceras jurense*, Ziet., as

Lytoceras jurense, *Ziet.*
Harpoceras insigne, *Schübl.*
— variabile, *d'Orbig.*
— Aalense, *Ziet.*
— striatulum, *Sow.*
Monotis substriata, *Münst.*
Goniomya angulifera, *Sow.*
Discina reflexa, *Sow.*
Lingula Beanii, *Phil.*
Rhynchonella Jurensis, *Quenst.*

The dark-grey calcareo-argillaceous nodules rest on the clays of the Upper Lias, or the true Alum-shale containing *Stephanoceras crassum*, *Steph. commune*, *Steph. fibulatum*, *Leda ovum*, and *Trigonia literata.*

Fossils of the Zone of Lytoceras Jurense.

Reptilia.

Vertebræ of *Ichthyosaurus.*

Pisces.

Teeth of *Hybodus.*

Cephalopoda.

Lytoceras Jurense, *Ziet.*
— hircinum, *Schlöth.*
Harpoceras insigne, *Schübler.*
— Comense, *von Buch.*
— Aalense, *Ziet.*
— discoides, *Ziet.*
— Thouarsense, *d'Orb.*
— striatulum, *Sow.*
— radians, *Reinecke.*
— Raquinianum, *d'Orb.*
— Levesquei, *d'Orb.*
Harpoceras Leckenbyi, *Lyc.*
— variabile, *d'Orb.*, var. Beanii, *Simp.*
— variabile, *d'Orb.*, var. dispansum, *Lyc.*
— obliquatum, *Young & Bird*, the aged form of variabile.
Nautilus latidorsatus, *d'Orb.*
Belemnites compressus, *Voltz.*
— tripartitus, *Schloth.*
— irregularis, *Schloth.*
— Nodotianus, *d'Orb.*

Gasteropoda.

Pleurotomaria subdecorata, *d'Orb.*
Chemnitzia lineata, *Sow.*
*Turbo capitaneus, *Münst.*
Trochus duplicatus, *Sow.*
*Natica adducta, *Phil.*
— Oppelensis, *Lyc.*

Lamellibranchiata.

*Lima bellula, var., *Lyc. & Mor.*
*Modiola plicata, *Sow.*
*Perna rugosa, *Münst.*
*Hinnites abjectus, *Phil.*
*Pecten articulatus, *Goldf.*
*Gresslya abducta, *Phil.*
* — conformis, *Agass.*
Myacites arenacea, *Lyc.*
*Homomya crassiuscula, *Lyc.*
Goniomya angulifera, *Sow.*
*Myoconcha crassa, *Sow.*
*Cypricardia cordiformis, *Desh.*
*Pecten comatus, *Münst.*
Opis carinatus, *Wright.*
* — lunulatus, *Sow.*
Cypricardia brevis, *Wright.*
Cardium Hullii, *Wright.*
— Oppelii, *Wright.*
Cucullæa ferruginea, *Lyc.*
Cucullæa oliviformis, *Lyc.*
*Lima electra, *d'Orb.*
Unicardium, nov. sp.
Tancredia, nov. sp.
Trigonia Ramsayii, *Wright.*
* — striata, *Sow.*
* — costata, *Sow.*
Pecten textorius, *Goldf.*
*Pholadomya fidicula, *Sow.*
— arenacea, *Lyc.*
Lima ornata, *Lyc. MS.*, nov. sp.
Astarte lurida, *Sow.*
* — excavata, *Sow.*
— detrita, *Goldf.*
— complanata, *Roemer.*
— rugulosa, *Lyc.*
Gervillia fornicata, *Lyc., MS.*
* — Hartmanni, *Goldf.*
Nucula Jurensis, *Quenst.*

Brachiopoda.

Terebratula subpunctata, *Dav.*
— trilineata, *Young.*
Rhynchonella cynocephala, *Rich.*
— Jurensis, *Quenst.*

In the above list the species marked with an asterisk are found likewise in the Inferior Oolite; but the specimens from the sands are nearly all dwarfed forms, showing that the physical conditions under which they lived were unfavorable to their development. The stunted growth of the stationary Lamellibranchs forms a striking contrast to the size, number, and variety of the locomotive Cephalopods interred with them in the same bed; the dawning existence of the former appears to have been a struggle for life, whilst the conditions under which the Cephalopods existed were favorable to their continuance in time, as shown by the number of species and individuals found in the Frocester beds; their life, however, was abruptly brought to a termination by some great physical change which took place about the commencement of the deposition of the Oolitic formations.

Foreign correlations. — The Jurensis-mergel was first pointed out by Professor Quenstedt[1] as the uppermost member of the "Shwarzer Jura," its importance in

[1] 'Flözgebirge Würtembergs,' pp. 267 and 539, 1843.

Württemberg as a distinct horizon demonstrated, and its leading fossils, *Lyt. Jurense*, *Harp. insigne*, *Harp. radians*, *Bel. digitalis*, and many others special to this zone, found at Balingen, Heiningen, Wasseralfingen, and other localities, were described. Upon the hard grey marls with *Lyt. Jurense* follow in Swabia beds of dark clay with *Lyt. torulosum*, as at Laufen and Metzingen. In Baden,[1] as at Langenbrücken and Mingolsheim, light grey calcareous marls with *Lyt. Jurense*, *Harp. radians*, *Bel. irregularis*, *Bel. tripartitus*, and *Bel. acuarius*, rest upon the Posidonomya-clays and form the uppermost beds of the Lias in this region.

In North Germany the *Jurense*-zone has been described by von Strombeck, Ewald, and Credner as found in the Helmstedt, Halberstadt, and Harzburg Jura, and in all these yielding its leading fossils as *Lyt. Jurense*, *Harp. insigne*, *Lyt. hircinum*, *Harp. variabile*, *Harp. striatulum*, and *Bel. irregularis*.

M. Terquem[2] has described a "Grès supra-liassique ou marly sandstone," near Metz, Moselle, which appears to represent this zone, as he has collected therefrom, in the environs of Thionville and at Longwy, several of the characteristic fossils of the *Jurense*-bed, as *Harp. insigne*, *Harp. radians*, *Bel. tripartitus*, together with Gastropods and Lamellibranchs belonging to this horizon.

At Silzbrunnen, Lower Elsace, my friend Professor R. Lepsius[3] has described the *Jurensis-Mergel*. The fossils he found were in very good condition, and the Ammonites had their shells well preserved. In the marl the group of *Harpoceras radians* was the most abundant. Here he collected likewise *Lyt. Jurense*, *Lyt. hircinum*, *Harp. insigne*, *Harp. Aalense*, *Harp. subplanatum*, *Harp. discoides*, with *Nucula Hammeri*, *Lima Galatea*, *Lima duplicata*, *Pecten textorius*, *Pentacrinus Jurensis*, and *Diastopora liasica*.

On the right bank of the Drôme, in the quarries of Suble, near Bayeux, above the calcareous and argillaceous strata, with *Harp. bifrons* and *Stephan. commune*, M. H. Harlé[4] discovered marly beds, two mètres thick, containing *Harp. opalinum*, *Harp. radians*, *Harp. Comense*, *Harp. variabile*, *Bel. tripartitus*, *Bel. abbreviatus*, *Bel. longisulcatus*, and *Rhyn. ringens*, which evidently represent the *Opalinum*- and *Jurense*-zones in Calvados.

At Thouars, Deux Sèvres, it will be seen (p. 137) that the strata Nos. 1—6 represent the *Jurense*-zone, which here rests conformably on the *Serpentinum*-beds. At Verpillière and St. Quentin (Isère) Dr. Oppel[5] collected *Harp. radians*, *Harp. costula*, *Harp. Thouarsense*, *Harp. Comense*, *Harp. insigne*, *Harp. Aalense*, *Harp. comptum*, *Harp. variabile*, *Lyt. Jurense*, and *Lyt. hircinum*.

[1] Leonhard, 'Geognost. Skizze des Grossherzog Baden,' p. 98, 1861.

[2] 'Paléontol. du Départ. de la Moselle,' p. 23, 1855.

[3] 'Beiträge zur Kenntniss der Juraformation in Unter-Elsass,' p. 13, 1875.

[4] 'Aperçu de la const. géologique du Dép. Calvados,' Annuaire, 1853.

[5] 'Juraformation Englands, Frankreichs, und des S.-W. Deutschlands,' p. 233, 1856.

M. Marcou,[1] in his 'Jura Salinois,' has described some beds as "Marnes à Trochus ou de Pinperdu," which contain the leading fossils of the "*Jurensis-Mergel*." In other Departments of France the same species of Ammonites have been collected, as, for example, near Fontenay (Vendée); Charolles, Saône-et-Loire; Mont d'Or, near Lyons, Rhône; Semur, Côte d'Or; &c., so that the *Jurense*-zone forms a well-defined horizon of life in the uppermost portion of the Upper Lias of France.

16. Zone of Harpoceras opalinum.

"Opalinus-Thone," Quenstedt, 'Flözgeb. Würtemb.,' pp. 281, 539, 1843. "Schict. des *Am. torulosus*," pars, Oppel, 'Jura-Formation,' p. 306, 1855. "Zone à *Am. opalinus*," Reynés, 'Géol. et Pal. Aveyron,' p. 63, 1868. "Zone à *Am. opalinus*," pars, Dumortier, 'Bassin du Rhône,' tom. iv, p. 278, 1874. "Thone der *Trigonia navis*," pars; "Zone des "*Am. torulosus*" Lepsius, 'Jura-Formation Unter-Elsass,' pp. 3, 14, 1875.

This zone was formerly grouped with the Cephalopoda-bed at Frocester; but, as it contains some species which are limited to this horizon and are associates of *Harpoceras opalinum*, it is best to treat it as the highest zone of the Lias. At Haresfield it forms a thin band of hard, ferruginous marl, which lies at the base of the Inferior Oolite in conformable position thereto. From this I have collected *Harpoceras opalinum*, Rein., *Macrodon Hirsonensis*, d'Arch., *Terebratula punctata*, David., var. *Rhynchonella cynocephala*, Rich., *Rhyn. furcillata*, Théod. I have had few Ammonites from this bed, and the other shells are not abundant. At Frocester Hill the upper portion of the Cephalopoda-bed contains several Ammonites, which have been described and figured by my old and esteemed friend Dr. Lycett.[2] One of these, *Harp. Moorei*, appears to resemble so much several specimens of *Harp. opalinum* from Gmünd, Boll, and Gundershofen, that I have no hesitation in regarding *Harp. Moorei* as a variety of *Harp. opalinum*, the form of the keel and the fine lines on the shell clearly showing the affinities. These localities are the only two I know in Gloucestershire, where this Ammonite is found. In Dorsetshire I have collected large beautiful specimens at Burton Bradstock, and at Chideock Hill, near Bridport, and have always found this species immediately beneath the Inferior Oolite. From the Haresfield bed I have taken a piece of rock having the impression of *Harp. opalinum* on its underside, whilst the block itself contained Inferior Oolite fossils; a fact which may afford an explanation how this Ammonite is considered by some to be an Oolitic species, and the progenitor of *Harp. Murchisonæ*. The *Opalinum*-

[1] 'Jura Salinois,' pp. 54 and 66, 1846.

[2] 'The Cotteswold Hills Handbook,' p. 122, pl. i, fig. 2, 1857.

bed at Haresfield and Frocester appears to be the boundary-line between the Lias and Inferior Oolite. In some lists of fossils I observe *Am. torulosus* entered as a species found at Frocester Hill; this, in my judgment, is a mistake. *Lyt. hircinum* occurs there, and may have been mistaken for it: I have not yet seen *Lyt. torulosum* in any English stratum or collection.

At Blue Wick, near Robin Hood's Bay, Yorkshire, this zone is represented by a band of dark friable shale, in parts micaceous and stained with ferric oxide, and containing *Terebratula trilineata*, *Rhynchonella cynocephala*, *Trigonia Ramsayi*, *Belemnites compressus*, and *Bel. irregularis*. The same species occur in a ferruginous seam of sandstone at Glaizedale, measuring eighteen inches in thickness, so that this bed in the north, as in the midland counties, is only feebly developed.

Foreign correlations.—The "*Opalinus-Thone*" was well described by Prof. Quenstedt,[1] as it occurs in Swabia, and *Am. opalinus*, *Am. torulosus*, *Bel. tripartitus*, *Trigonia navis*, *Gervillia pernoides*, *Cardium striatulum*, *Mya angulifera*, *Nucula Hammeri*, and *Astarte lurida* were enumerated as its leading fossils.

Dr. Oppel[2] found the beds in Württemberg in the Swabian Alps; and near Gmünd, Boll, Metzingen, Gomaringen, and Mässingen, in Bavaria, in the neighbourhood of Altdorf, and Neumarkt, and in Baden, near Kander. Many of the leading shells figured by Goldfuss in his 'Petrefacta Germaniæ' were collected from this bed at Banz, and near Boll.

In North Germany this zone has been detected in many localities. Reinecke[3] first figured *Harp. opalinum* from a specimen collected near Alten-Banz, Coburg. Rolle[4] recognised the stratum near Hildesheim, Goslar, and Quedlinburg, and first compared the fossils he collected from these beds with those he had found in strata of the same age in Swabia. Von Strombeck[5] discovered the zone near Schoppensted, and Ewald[6] found the same near Hoym in Saxony. Von Seebach[7] met with this horizon near Wentzen, at the southern margin of Hils, and likewise in a railway-cutting south-east of Greene, from which he obtained a collection of its leading fossils, including *Lyt. hircinum* and *Harp. opalinum*. Dr. Lepsius[8] carefully studied this zone in Lower Elsace, and has given an exhaustive account of the beds in his interesting memoir. I had the pleasure of showing my friend the Frocester Hill section of the Cephalopoda-bed and *Jurense*-sands, and he at once recognised the marked lithological resemblance they had to their correlative zone in Lower Elsace, upon the study of which he was then engaged.

[1] 'Flözgebirge Würtembergs,' pp. 243 and 539, 1843

[2] 'Juraformation,' p. 308, 1856.

[3] 'Maris protogaei Cornu Amm. in Agro Coburgico,' pl. i, fig. 1, 1818.

[4] 'Versuch einer Vergl. des Norddeutschen Lias mit dem Schabischen,' 1853.

[5] 'Thon mit Am. opalinus,' Zeitschr. d. Deut. geol. Gessell., vol. v, p. 102, 1853.

[6] 'Schict. des Am. opalinus,' Sitzber. d. Berlin Akad., April, p. 350, 1859.

[7] 'Der Hannoversche Jura,' p. 3, 1864.

[8] 'Der Juraformation in Unter-Elsass,' p. 4, 1875.

In France *Harp. opalinum* and *Lyt. torulosum*, which may be regarded as the leading fossils of this zone, have been collected at Vassy, Yonne; at Villenote, near Sémur, Côte d'Or; at Salins, Jura; and Besançon, Doubs; at Amende, Lozère; at Fontenay, Vendée; and at Charolles, Saône-et-Loire; and I obtained a number of Ammonites from Milhau, Aveyron; which all belong to the same zone. Dumortier[1] has given a list of several localities in which he has found this zone in the Rhone Valley, and has especially noted la Verpillière, Isère; where the workings for iron-ore in this region bring the many beautiful fossils of this zone into collectors' hands, as *Belemnites exilis*, *Bel. tricanaliculatus*, *Bel. Dorsetensis*, *Bel. pyramidalis*, *Nautilus lineatus*, *Harp. opalinum*, *Harp. Aalense*, *Harp. mactra*, *Harp. costula*, *Harp. fluitans*, *Harp. subinsigne*, *Harp. crassifulcatum*, *Harp. Briordense*, *Harp. Allconi*, *Harp. Lorteti*, *Harp. fallax*, *Lyt. hircinum*, and *Lyt. torulosum*, all of which Dumortier refers to the *Opalinum*-zone.

The Inferior Oolite and its Ammonite-zones.

The zone of *Harpoceras opalinum* is so closely related to that of *Harpoceras Murchisonæ* that I consider a short account of the latter a proper complement to my sketch of the Upper Lias. The affinities and differences between these two formations will then be placed fairly before the student, and the reasons be made evident for my definition of the limits of the Lias formation.

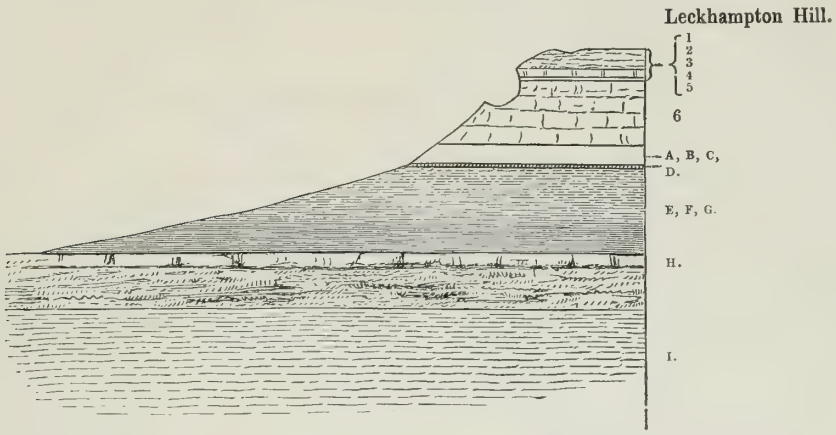
Leckhampton Hill, near Cheltenham, exhibits one of the most typical sections in Gloucestershire of the three sub-divisions of the Inferior Oolite, where the following beds are admirably exposed :—Fig. 11, Nos. 1, 2, and 3 represent the zone of *Cosmoceras Parkinsoni*; No. 4 the zone of *Stephanoceras Humphriesianum*; Nos. 5, 6, and A, B, C, the zone of *Harpoceras Murchisonæ*; those rest comformably on D, the Cephalopoda- or *Jurense*-bed, which is here very thin; E, F, G, is the Upper Lias resting on H, the Marlstone.

No. 1. The *Upper Trigonia-bed* is a coarse brown ragstone, containing many fossils, chiefly as moulds and impressions of *Trigonia costata*, Sow., *T. decorata* Lyc., *Lima cardiiformis*, Sow., *Rhynchonella concinna*, Sow., *Terebratula spinosa*, Schl., *Cosmoceras Parkinsoni*, Sow., *Echinobrissus clunicularis*, Lhywdd, *Holectypus depressus*, Leske, and *Clypeus Plotii*, Klein; in thickness it is about seven feet.

No. 2. The *Gryphæa-bed*, an ancient oyster-bank, is almost entirely composed of *Gryphæa sublobata*, Desh., accompanied with *Pholadomya Heraulti*, Agass., *Terebratula Meriani*, Opp., *Tancredia donaciformis*, Lyc., *Gervillia tortuosa*, Phil., and many other species; but the dominant shell is the *Gryphæa*; this bed is about eight feet in thickness.

[1] 'Depôts Jurass. du Bassin du Rhône,' t. iv, p. 237, 1874.

Fig. 11.—*Section of Leckhampton Hill, near Cheltenham.*



1. Trigonia-bed.
2. Gryphæa-bed.
3. Brown rubbly oolite.
4. Flaggy freestone.
5. Fimbria-bed or Oolite-marl.
6. Freestone.

A, B, C. Pea-grit and ferruginous oolite.
D. Cephalopoda- or *Jurense*-zone.
E, F, G. Upper Lias sand and Upper Lias clay.
H. Marlstone.
I. Middle Lias clay; zone of *Aegoceras Capricornus*.

No. 3. The *Lower Trigonia-bed*, a light-coloured, thin-bedded oolitic ragstone, containing a large assemblage of *Lamellibranchiata*, which in general have their shells preserved, with several species of *Echinodermata* and *Anthozoa*.

No. 4. Upper flaggy bastard-freestone, well seen above the Oolite-marl: twenty-six feet thick. It represents the zone of *Stephanoceras Humphriesianum;* this rock is here almost non-fossiliferous, although the equivalent bed at Cleeve Hill contains a rich fauna.

No. 5. The *Fimbria-bed* or Oolite-marl, is a cream-coloured mud-stone, not unlike chalk-marl; the dominant shells are *Terebratula fimbria*, Sow., *Tereb. carinata*, Lamk.; it contains likewise *Lucina Wrighti*, Oppel., *Lima punctata*, Phil., *L. Pontonis*, Lyc., *Natica Leckhamptonensis*, Lyc., *Natica adducta*, Phil., *Mytilus pectinatus*, Sow., *Astarte elegans*, Sow., *Nerinæa*, sp., *Chemnitzia*, sp., and masses of Coral, chiefly *Thamnastræa Mettensis*, Edw. This bed was deposited under conditions very different to that of the freestone on which it rests; its lower portion is slightly brecciated, and the surface of the freestone on which that breccia was deposited had been for some time exposed to aqueous action and made smooth thereby. The marl measures about seven feet in thickness, and passes upwards into a marly limestone, becoming oolitic in the uppermost layers. This division of the bed is about ten feet thick. The *Fimbria*-bed is a constant feature in the Lower Oolite of the Cheltenham district, and in the northern and middle Cotteswolds, but is absent in the southern parts of the range. It forms the upper part of the zone of *Harpoceras Murchisonæ*.

No. 6. The *Freestone* is a compact light-coloured oolitic limestone; the uppermost

beds are the best for building-purposes; the middle beds are of an inferior quality, and are stained in part with ferric oxide; the lower beds, called "Roestone," contain large oolitic grains; the freestone in all is about 110 feet in thickness.

The Pea-grit (Zone of Harpoceras Murchisonæ), Inferior Oolite.

		Ft.	in.
A.	A brown, coarse, rubbly oolite, full of flattened concretions cemented together by a calcareous matrix. When the blocks weather, the concretions, which resemble flattened peas, form a very uneven surface. It contains many fossils in good preservation	12	0
B.	A hard, cream-coloured, pisolitic rock, made up of flattened concretions, with a thickness about similar to those in A	10	0
C.	A coarse, brown, ferruginous rock, composed of large oolitic grains; it is readily disintegrated by the frost, and is of little economical value. About.....	20	0

The Cephalopoda-bed (Zone of Lytoceras Jurense), Upper Lias.

D.	A brown marly rock, full of small dark oolitic grains of the hydrate of iron, which are strewed in profusion in a calcareous paste. About	2	0
D′.	A thin seam of yellowish sand	0	1¼

Upper Lias Sand and Clay.

E.	A dark-grey crystalline limestone, extremely hard, and resembling some beds of the Carboniferous Limestone; it is bored in different places by *Fistulana?* the shells of which remain in the excavations. Thickness not exposed.....	?	
F.	A brown, argillaceous, sandy bed, full of micaceous particles; passing downwards into fine brown and yellow sands. Thickness unknown	?	
G.	Upper Lias clay, of a dark blue colour. Thickness probably.....	160	0

Fossils of the Pea-grit and Freestones.

Cephalopoda.

Harpoceras Murchisonæ, *Sow.*
Nautilus truncatus, *Sow.*
Belemnites spinatus, *Quenst.*
— abbreviatus, *Mill.*

Gasteropoda.

Patella rugosa, *Sow.*
— inornata, *Lyc.*
Pileolus lævis, *Sow.*
Nerita costata, *Sow.*
— minuta, *Sow.*
Monodonta Lyelli, *d'Arch.*
— sulcosa, *d'Arch.*
Natica adducta, *Phil.*
Cirrus nodosus, *Sow.*
Trochotoma carinata, *Lyc.*
Turbo elaboratus, *Lyc.*
Trochus monilitectus, *Phil.*
Solarium Cotswoldiæ, *Lyc.*
Nerinæa cingenda, *Bronn.*
Actæonina Sedgvici, *Phil.*
Alaria spinifera, *Lyc.*

Lamellibranchiata.

Ostrea costata, *Sow.*
Placunopsis Jurensis, *Roem.*
Hinnites velatus, *Goldf.*
Limea duplicata, *Goldf.*
Lima sulcata, *Münst.*
— lyrata, *Münst.*
— Lycetti, *Wright.*
— bellula, *Mor. & Lyc.*
Pecten comatus, *Münst.*
— Dewalquei, *Oppel.*
Mytilus furcatus, *Münst.*
— striatulus, *Goldf.*
Modiola Sowerbyana, *d'Orb.*
Avicula complicata, *Buck.*
Corbula involuta, *Goldf.*
Tancredia axiniformis, *Phil.*
Arca Prattii, *Mor. & Lyc.*
Arca pulchra, *Sow.*
— cancellata, *Phil.*
— lata, *Dunk.*
Trigonia costata (var. pulla), *Sow.*
— exigua, *Lyc.*
Astarte interlineata, *Lyc.*
— rhomboidalis, *Phil.*
Sphæra Madridi, *d'Arch.*
Cyprina trapeziformis, *Roem.*
Unicardium, nov. sp.
Myoconcha crassa, *Sow.*
Ceromya Bajociana, *d'Orb.*
Myopsis rotundata, *Buck.*
Cardium striatulum, *Phil.*
— lævigatum, *Lyc.*
Goniomya angulifera, *Sow.*
Pinna cuneata, *Bean.*

Brachiopoda.

Terebratula simplex, *Buck.*
— plicata, *Buck.*
— submaxillata, *Dav.*
— carinata, *Lamk.*
Rhynchonella Wrightii, *Dav.*
— decorata, *Dav.*
— angulata, *Sow.*
— oolitica, *Dav.*

Annelida.

Serpula grandis, *Goldf.*
— convoluta, *Goldf.*
— plicatilis, *Münst.*
Serpula quadrilatera, *Goldf.*
— flaccida, *Goldf.*

Echinodermata.

Cidaris Fowleri, *Wright.*
— Bouchardii, *Wright.*
— Wrighti, *Desor.*
Rhabdocidaris Wrightii, *Desor.*
Acrosalenia Lycettii, *Wright.*
Pseudodiadema depressum, *Agass.*
Stomechinus germinans, *Phil.*
Polycyphus Deslongchampsii, *Wright.*
Pedina Bakeriæ, *Wright.*
Hemipedina tetragramma, *Wright.*
— perforata, *Wright.*
— Bonei, *Wright.*
Pygaster semisulcatus, *Phil.*
— conoideus, *Wright.*
Galeropygus agariciformis, *Forb.*
Stellaster obtusus, *Wright.*
Pentacrinus Desori, *Wright.*
— Loriolii, *Wright.*

Polyzoa.

Stromatopora dichotomoides, *d'Orb.*
Diastopora Waltonii, *Haime.*
— Mitchelini, *Haime.*
— Mettensis, *Haime.*
— Wrightii, *Haime.*
Spiropora straminea, *Phil.*
Lichenopora Phillipsii, *Haime.*
Neuroptera demicornis, *Lamour.*
Heteropora conifera, *Lamour.*
— pustulosa, *Mechelini.*
Theona Bowerbankii, *Haime.*
Berenicea diluviana, *Lamour.*

ANTHOZOA.

Montlivaltia Delabechei, *Edw. & Haime.*
— Waterhousei, *Edw. & Haime.*
— cupuliformis, *Edw. & Haime.*
Axosmilia Wrightii, *Edw. & Haime.*
Latomæandra Flemingii, *Edw. & Haime.*
Isastræa tenuistriata, *Edw. & Haime.*
— limitata, *Edw. & Haime.*
Thamnastræa Mettensis, *Edw. & Haime.*
— Defranciana, *Edw. & Haime.*
— fungiformis, *Edw. & Haime.*

The annexed generalised section of Cleeve Hill, Gloucestershire, gives all the Inferior Oolite beds in their relative position, and at the same time shows how they rest conformably on the *Lytoceras Jurense* zone beneath. The beds are described in descending order, commencing with those exposed at the summit of the hill.

I divide the Inferior Oolite in this county into three zones :—

A. Zone of *Cosmoceras Parkinsoni.*
B. Zone of *Stephanoceras Humphriesianum.*
C. Zone of *Harpoceras Murchisonæ.*

DESCRIPTION OF THE CLEEVE HILL SECTION.

A. THE ZONE OF *Cosmoceras Parkinsoni.*

No. 1 in fig. 12, consists of α, rubbly oolite above, hard slabs of ragstone in the middle, and a clayey bed below, passing into β, a sandy oolite of a rich brownish colour, freely specked with ferruginous grains of silicate of iron. I have obtained the following fossils therefrom :—

CEPHALOPODA.

Cosmoceras Parkinsoni, *Sow.*
Perisphinctes Martinsii, *d'Orb.*
Nautilus lineatus, *Sow.*
Belemnites canaliculatus, *Schloth.*

GASTEROPODA.

Pleurotomaria fasciata, *Sow.*
Trochotoma carinata, *Lyc.*
Natica adducta, *Phil.*
Monodonta lævigata, *Sow.*

LAMELLIBRANCHIATA.

Trigonia costata, *Sow.*
Pholadomya ovulum, *Agass.*
— fidicula, *Sow.*
— Heraulti, *Agass.*
Myopsis dilatata, *Phil.*
Goniomya angulifera, *Sow.*
Lima proboscidea, *Sow.*
— gibbosa, *Sow.*
Lima compressa, *Wright.*
Gryphæa sublobata, *Desh.*
Trichites undulatus, *Lyc.*
Gervillia Hartmanni, *Goldf.*
Opis cordiformis, *Lyc.*
Modiola Sowerbii, *d'Orb.*
— bipartita, *Sow.*
— imbricata, *Sow.*

FIG. 12.—*Section of the Inferior Oolite at Cleeve Hill, Gloucestershire.*

INFERIOR OOLITE.

Western Slope of the Hill. — Upper Freestone Quarry. — North Quarry. — Rolling Bank. — Summit.

No.	ft.	in.	
			TRIGONIA-GRIT. *Cosmoceras Parkinsoni* and Corals.
			Thecosmilia gregaria, Thamnastræa, Isastræa, &c.
			Gryphæa sublobata, Lima proboscidea, Trigonia costata.
1	6		CHEMNITZIA-GRIT. *Chemnitzia procera.*
2	1	6	Rubbly Oolite.
3	2		BRACHIOPODA-BED. *Terebratula Phillipsii*, in clusters.
4	2	6	ROAD-STONE. *Stephanoceras Humphriesianum, Chemnitzia Sæmanni.*
5	10		OYSTER-BED. *Ostrea flabelloides, Lima Etheridgii.*
6	3		Not known.
7	5		Yellow and brown Sands, with lenticular nodules of Sandstone.
8	3		Hard wavy Sandstone. *Serpula socialis*, abundant.
9		8	Marly Oolite.
10	12		UPPER FREESTONE, with old *Terebratula fimbria.*
11	4		Thin flaggy Oolite.
12	8		OOLITE-MARL. *Lucina Wrightii, Terebratula fimbria.*
13	1	6	Thin hard bands of Limestone.
14	4	6	Thin beds of fine-grained oolitic Limestone.
15	5		Hard rubbly oolitic Marl, in broken masses.
16	26		LOWER FREESTONE: the Upper Terrace.
17	40	2	LOWER FREESTONE: the Lower Terrace.
18	2		Hard beds of pisolitic Oolite.
19	4		Buff-coloured pisolitic Limestone.
20	1	6	ROE-STONE. *Pseudodiadema depressum, Acrosalenia Lycetti, Trochotoma carinata.*
21	30?		PEA-GRIT. *Pygaster semisulcatus, Harpoceras Murchisonæ, Patella rugosa, Ammites velatus, Avicula complicata, Terebratula simplex, Terebratula plicata.*
22	5		Coarse ferruginous Oolite.
23	2		LIASSIC SANDS or JURENSE-ZONE. Highly ferruginous.
			UPPER LIAS. *Harpoceras bifrons* Zone.

ANTHOZOA.

Thecosmilia gregaria, *Edw. & Haime.*
Isastræa tenuistriata, *Edw. & Haime.*
Thamnastræa Defranciana, *Michelin.*
Latomæandra Davidsonii, *Edw. & Haime.*
Montlivaltia Wrightii, *Edw. & Haime.*
— Delabechei, *Edw. & Haime.*

No. 2. *Chemnitzia-grit* is a thin band of brownish marl and clay, in which are sometimes found specimens of *Chemnitzia procera*, DESLONG., and moulds of *Nerinæa*. Fishes' teeth are occasionally collected in this band.

No. 3. *Rubbly Oolite.*—Consisting of oolitic ragstones, in a fragmentary state, with few fossils. This bed caps the next division.

B. THE ZONE OF *Stephanoceras Humphriesianum.*

No. 4. The *Brachiopoda*-bed is a compact crystalline buff-coloured limestone; many blocks of great hardness are almost entirely composed of the shells of *Terebratula Phillipsii*. It measures two feet six inches, and contains the following species of fossils :

Lima proboscidea, *Sow.*
Terebratula Phillipsii, *Mor.*
— perovalis, *Sow.*
— carinata, *Lamk.*
Terebratula Buckmani, *Davids.*
Rhynchonella spinosa, *Schloth.*
— subtetrahedra, *Davids.*
— angulata, *Sow.*

On one occasion, by digging into the floor of the quarry, I found a bed of marly oolite, or mudstone; it contained many fossils, the shells of which were in such a perished condition that I could not determine all the species. I noted, however, the following :—

Chemnitzia.
Nerinæa.
Modiola plicata, *Sow.*
Pecten comatus, *Münst.*
Cypricardia cordiformis, *Desh.*
Terebratula Etheridgii, *Davids.*
Montlivaltia, species.

No. 5. The *Road-stone* consists of a coarse, brown, ferruginous, oolitic limestone, hard and crystalline in some parts, and in others traversed by sandy layers, containing concretionary masses of calcareo-siliceous rock, having an unequal fracture and crystalline structure. It contains a small assemblage of Mollusca, many of which are specifically distinct from those of the upper beds, as *Chemnitzia Sæmanni*, Oppel, nearly identical with the Coralline-oolite species, *C. striata*, Sow., gigantic forms of *Pholadomya Heraulti*, Ag., and very large shells of *Trichites undulatus*, Lyc. This bed varies in thickness from ten to fifteen feet.

Cephalopoda.

Stephanoceras Orbignianum, *Wright.*
— Humphriesianum, *Sow.*
— Sowerbii, *Mill.*
Stephanoceras Brocchi, *Sow.*
— Braikenridgii, *Sow.*
Nautilus lineatus, *Sow.*

Gasteropoda.

Chemnitzia Sæmanni, *Oppel.*
— lineata, *Sow.*
Turbo lævigata, *Sow.*
Pleurotomaria fasciata, *Sow.*
— elongata, *Sow.*
— constricta, *Deslong.*

Lamellibranchiata.

Ostrea flabelloides, *Lamk.*
— large flat, new species.
Hinnites tuberculosus, *Göldf.*
Lima proboscidea, *Sow.*
— Etheridgii, *Wright.*
— duplicata, *Sow.*
Trichites undulatus, *Lyc.*
Astarte excavata, *Sow.*
Cyprina (mould).
Cypricardia cordiformis, *Desh.*
Myacites calceiformis, *Sow.*
Gervillia consobrina, *d'Orb.*
Mytilus explanatus, *Mor.*
Pholadomya Heraulti, *Agass.*
Homomya crassiuscula, *Lyc.*
Myoconcha crassa, *Sow.*
Pteroperna plana, *Lyc.*
Trigonia costata, *Sow.*
— striata, *Sow.*
— decorata, *Agass.*
Modiola imbricata, *Sow.*
Pinna fissa, *Phil.*

No. 6. The *Oyster-bed* consists of a coarse, brown, ferruginous, sandy marl, with inconstant layers of hard rock, which breaks up unequally. It is chiefly in the sandy seams that the fossils are found. The bed is about a yard in thickness. The bottom is seldom exposed, as it is mainly for the roadstone that the working is carried on. It contains:

Conchifera.

Ostrea flabelloides, *Lamk.*, and several well-marked varieties of the species.
— pyxiformis, *Wright.*
Pecten demissus, *Goldf.*
Lima proboscidea, *Sow.*
— Etheridgii, *Wright.*
Monotis tenuicostata, *Wright.*
Gresslya abducta, *Phil.*
Pleuromya tenuistriata, *Agass.*
Pholadomya Heraulti, *Agass.*
— ovulum, *Agass.*
— media, *Agass.*
— Dewalquei, *Lyc.*

Annulosa.

Serpula grandis, *Goldf.*
Serpula limax, *Goldf.*

Echinodermata

Clypeus Michelini, *Wright.*
Stomechinus germinans, *Phil.*
Pseudodiadema depressum, *Agass.*
Acrosalenia Lycetti, *Wright.*

No. 7. *Calcareo-siliceous Sand.*—Of a brown, grey, or yellow colour. It forms the uppermost bed in the North Quarry, and constitutes the subsoil over a considerable area of this part of the hill. It has been much denuded in parts; measures in some places five feet in thickness, and is unfossiliferous. I know of no other bed in our district which presents lithological characters similar to those of this sandy stratum.

No. 8. *Wavy Sandstone.*—This is a hard, brown, thin-bedded rock, with a wavy stratification; it is siliceous in some parts, and calcareous in others. The siliceous portions are unfossiliferous; the calcareous are represented by slabs of thin ragstones, containing many fossils. On some of these I found *Serpula socialis*, Goldf., in great abundance. This bed has a thickness of three feet, and rests on

No. 9. *Marly Oolite.*—Broken up into fragmentary portions. It appears to be the upper portion of the Upper Freestone.

No. 10. *Upper Freestone.*—A thick-bedded, coarse-grained oolitic limestone, used for rough work. This rock was long thought to be unfossiliferous; and considerable doubts were entertained as to the precise position of these beds in the series. During my last visit, however, I succeeded in obtaining from the lower and middle beds a few specimens of large, old, deformed *Terebratula fimbria*, Sow., which enabled me to determine its position as superior to the Oolite-marl, and to identify the rock as the Upper Freestone. It has a thickness of twelve feet.

c. The Zone of *Harpoceras Murchisonæ*.

No. 11. *Thin flaggy Oolite.*—This rock splits into thin layers. Numerous shelly fragments are found in some slabs, but fossils are rare; thickness, four feet.

No. 12. *Fimbria-bed or Oolite-marl.*—This bed is well exposed on the western side of the hill, and consists of a cream-coloured marl, like indurated Chalk, interstratified between two beds of oolitic limestone, resting upon the uppermost bed of the Lower, and overlain by the thin flaggy beds of the Upper Freestone. It forms a very persistent stratum in the Northern and Middle Cotteswolds, extending across this portion of the *plateau*, from the vales of Morton and Bourton on the east, to the mural escarpments of the Inferior Oolite on the west, but thinning out and disappearing in the southern part of the range. In some localities, as at Leckhampton, Sheepscombe, and Swift's Hill, near Stroud, it contains masses of Corals, of the genera *Thamnastræa* and *Isastræa;* in others, as near Nailsworth, it abounds with numerous shells of the genus *Nerinæa*, forming there a "Nerinæan Limestone;" in others, as at Cleeve and Cubberley, the marl is charged with *Brachiopoda*, chiefly *Terebratula fimbria*, Sow., associated with a few *Terebratula carinata*, *T. submaxillata*, and *Rhynchonella Lycetti*. The fauna of the Oolite-marl induced me, in a former paper thereon, to consider this bed as the product of an ancient Coral-bank. "The direct evidence of the existence of *Anthozoa* in

considerable numbers, added to the abundance of" long spiral univalves belonging to the genera *Chemnitzia* and *Nerinæa*, which are known to " nestle in Coral-formations, together with the indirect evidence of a superabundance of *Brachiopoda*, added to the lithological character of the marl itself, which appears to be the product of Coral-mud and other reef *débris*, leads to the conclusion that the *Oolite-marl* is a portion of a Jurassic Coral-bank." [1]

Mollusca.

Chemnitzia procera, *Deslong.*	Mytilus imbricatus, *Sow.*
Nerinæa gracilis, *Lyc.*	Lima punctata, *Phil.*
Natica adducta, *Phil.*	— Pontonis, *Lyc.*
Trochotomia calyx, *Lyc.*	Arca cancellata, *Phil.*
Trochus monilitectus, *Phil.*	Lucina Wrightii, *Oppel.*
Monodonta lævigata, *Sow.*	Myopsis punctata, *Buck.*
Natica macrostoma, *Roem.*	Ceromya concentrica, *Sow.*

Brachiopoda.

Terebratula submaxillata, *Davids.*	Rhynchonella Lycetti, *Davids.*
— fimbria, *Sow.*	— concinna, *Sow.*
— carinata, *Lamk.*	— angulata, *Sow.*

Echinodermata.

Stomechinus germinans, *Phil.*	Pseudodiadema depressum, *Agass.*
Pedina Smithii, *Forb.*	Acrosalenia Lycetti, *Wright.*

No. 13. *Thin hard bands of Oolitic Limestone*, without fossils, eighteen inches.

No. 14. *Thin beds of fine-grained Oolitic Limestone*, four feet six inches.

No. 15. *Hard Rubbly Oolite-marl.*—This occurs in broken masses five feet thick.

These three beds are well exposed in a small escarpment on the western slope of the hill, near the large Freestone Quarry. They contain few fossils, and the rock is much shaken.

No. 16. *The Lower Freestone* attains a considerable thickness in Cleeve Hill, and has long been extensively raised there for building-purposes. It is divisible into two terraces, the upper of which contains the best beds of stone. The rock is a fine-grained thick-bedded oolitic limestone, remarkably free from organic remains and ferruginous stains. The upper terrace is twenty-six feet in thickness.

No. 17. *The Lower Freestone.*—The lower terrace is exposed on the western escarpment of the hill. The rock is not equal in quality to the beds in the upper terrace, and it is therefore not now worked for building-stone. Its exact thickness I have not ascertained, but I estimate it at forty feet.

[1] Wright, " On the Sub-divisions of the Inferior Oolite," 'Quart. Journ. of the Geol. Soc.,' vol. xvi, p. 13, 1860.

No. 18. *Hard beds of Pisolitic Oolite,* and

No. 19. *Buff-coloured Pisolitic Limestone,* forming a kind of transitional lithological condition from the oolitic limestones of the Freestone to the beds of Roestone and Pea-grit.

No. 20. *The Roestone* forms the base of the Freestone series. It consists of a whitish limestone, composed of large oolitic grains, and containing a great variety of small Shells, Corals, and Echinoderms, in very fine preservation. In some respects the general *facies* of the fauna of the Roestone resembles that of the Great Oolite of Minchinhampton. Many of the Mollusca are specifically distinct, and others are identical with those of that formation. The shells are nearly all small, and well preserved. In some the colouring matter of the shell is present, and there are many undescribed species in the series; many beautiful *Alariæ*, with their long spines, were obtained from this bed at Leckhampton; and my old friends, the Rev. P. B. Brodie and Dr. Lycett, collected, determined, and published, in 1850, a full list of these remains. I have not worked this bed at Cleeve Hill with much attention, but in a short time I collected many of the species of my friends' list.

Anthozoa.

Caryophyllia. Thecosmilia. | Montlivaltia. Isastræa.

Echinodermata.

Pseudodiadema depressum, *Ag.*
Acrosalenia Lycetti, *Wright.*
Stomechinus germinans, *Phil.*
Polycyphus Deslongchampsii, *Wr.*

Lamellibranchiata.

Astarte orbicularis, *Sow.*
— depressa, *Münst.*
Arca pulchra, *Sow.*
Avicula complicata, *Buck.*
Cardium cognatum, *Phil.*
Cucullæa elongata, *Sow.*
— oblonga, *Phil.*
Corbula curtansata, *Phil.*
Hinnites velatus, *Goldf.*
Psammobia lævigata, *Phil.*
Gervillia costatula, *Deslong.*
Cypricardia cordiformis, *Desh.*
Limea duplicata, *Sow.*
Lucina despecta, *Phil.*
Mytilus asper, *Sow.*
Nucula variabilis, *Sow.*
Ostrea costata, *Sow.*
Pecten comatus, *Münst.*
— Dewalquei, *Oppel.*
Trigonia striata, *Sow.*

Brachiopoda.

Terebratula simplex, *Buck.*
Terebratula plicata, *Buck.*

Gasteropoda.

Patella rugosa, *Sow.*
— nitida, *Deslong.*
Pileolus lævis, *Sow.*
Natica adducta, *Phil.*
Nerita costata, *Sow.*
Alaria (three new species).

Rimula clathrata, *Sow.*
Solarium (two new species).
Emarginula tricarinata, *Sow.*
Fissurella acuta, *Deslong.*

No. 21. *The Pea-grit* is one of the most remarkable beds of the Inferior Oolite in the district. It invariably claims the most marked attention from all the continental Oolitic Geologists to whom I have shown our local sections, as it is unlike any bed they are acquainted with in France or Germany. Its upper part consists of—*α*. A hard, coarse, brown, rubbly Oolite, full of flattened concretions, cemented together by a calcareous matrix. When the blocks weather, the concretions resemble flattened peas, and form an uneven surface. In the cavities of the Pisolite beautiful Echinidæ are often found in great perfection, and many other fossils are very well preserved therein. *β*. A hard, cream-coloured, pisolitic rock, made up of compressed, flattened concretions like those of *α*; the bed is more compact in parts. *γ*. A coarse, brown, ferruginous Ragstone, full of large oolitic grains and much ferric oxide; it is readily disintegrated by frost. The three beds measure from thirty to forty feet in thickness. The Pea-grit varies considerably in development in different localities. Crickley, Leckhampton, Birdlip, and Cleeve Hills afford the best types of this bed.

Cephalopoda.

Harpoceras Murchisonæ, *Sow.*
Nautilus truncatus, *Sow.*
Belemnites spinatus, *Quenst.*
— abbreviatus, *Mill.*

Gasteropoda.

Patella rugosa, *Sow.*
— inornata, *Lyc.*
Pileolus lævis, *Sow.*
Nerita costata, *Sow.*
Natica adducta, *Phil.*
Cirrus nodosus, *Sow.*
Turbo capitaneus, *Münst.*
Trochotoma carinata, *Lyc.*

Lamellibranchiata.

Ostrea gregaria, *Sow.*
Placunopsis, sp.
Hinnites abjectus, *Phil.*
Mytilus imbricatus, *Sow.*
Lima sulcata, *Münst.*
— pectiniformis, *Schloth.*
— duplicata, *Goldf.*
— lyrata, *Münst.*
— Lycetti, *Wright.*
Astarte excavata, var., *Sow.*
Myopsis rotundata, *Buck.*
Goniomya angulifera, *Sow.*
Avicula complicata, *Buck.*
Ceromya Bajociana, *d'Orb.*
Cardium striatulum, *Phil.*
— lævigatum, *Lyc.*
Pinna cuneata, *Bean.*
Pecten comatus, *Münst.*

Brachiopoda.

Terebratula simplex, *Buck.*
— plicata, *Buck.*
Rhynchonella Lycetti, *David.*
— subtetrahedra, *David.*

ECHINODERMATA.

Pseudodiadema depressum, *Agass.*
Cidaris Fowleri, *Wright.*
— Bouchardii, *Wright.*
— Wrightii, *Desor.*
Diplocidaris D sori, *Wright.*
— Wrightii, *Desor.*
Stomechinus germinans, *Phillips.*
Acrosalenia Lycetti, *Wright.*
Hemipedina Bakeriæ, *Wright.*
Hemipedina perforata, *Wright.*
— tetragramma, *Wright.*
— Waterhousei, *Wright.*
Polycyphus Deslongchampsii, *Wright.*
Pygaster semisulcatus, *Phillips.*
— conoideus, *Wright.*
Galeropygus agariciformis, *Forbes.*
Goniaster obtusus, *Wright.*
Pentacrinus Austenii, *Wright.*

ANTHOZOA.

Latomæandra Flemingii, *Edw. & Haime.*
— Davidsonii, *Edw. & Haime.*
Axosmilia Wrightii, *Edw. & Haime.*
Thamnastræa Terquemi, *Edw. & Haime.*
Thamnastræa Mettensis, *Edw. & Haime.*
— Defranciana, *Edw. & Haime.*
— fungiformis, *Edw. & Haime.*
Isastræa tenuistriata, *Edw. & Haime.*

No. 22. *The Coarse Ferruginous Oolite* is composed of large oolitic grains of calcic carbonate, having incorporated therewith a considerable percentage of the ferric oxide. This rock has a fine rich brown colour, and when exposed in the escarpment, and lit by the sun's rays, it imparts a warm colouring to the surrounding landscape, varying in its tones from one hour to another. I know of no part of the Cotteswold range which exhibits more picturesque effects and play of colour than the bold naked escarpment of Cleeve Hill, and to which the beds forming this portion of the section so largely contribute by their deep rich tints. The rock is of little value as a road-stone, because it is readily disintegrated by rain and frost; it might have some economic value for the Iron it contains, if the percentage of that mineral were sufficiently large to be remunerative, but no quantitative analysis has yet been made to ascertain its proportions. I have found few fossils in this bed at Cleeve. Belemnites and Pholodomyæ are occasionally met with.

No. 23. *The Upper Liassic Sands* or zone of *Lytoceras Jurense* so well developed at Cooper's Hill, Haresfield Beacon, Nailsworth, the Long Wood near Frocester, Uley Bury, Stinchcombe, the hills around Dursley, and at Nibley, Wotton-under-Edge, Ozleworth, and all along the chain of the southern Cotteswolds as far as Bath, are only feebly represented at Cleeve. These Sands afford an example of that thinning-out process which is seen to a greater or less extent in all the other beds in our section, if traced in certain directions from the point where they attain their maximum development. As a general rule it may be stated that all the Inferior-Oolitic rocks thin out from their western escarpment in the Cotteswolds when traced eastwards, and that the Liassic Sand or *Jurense* zone gradually thickens when traced from the northern to the southern part of the chain.

A Table showing the Stratigraphical Distribution of the Ammonoida in the Upper Lias of the British Islands.

Families, Genera, and Species.	Serpentinum.	Bifrons.	Jurense.	Opalinum.
Family—LYTOCERATIDÆ.				
Genus—LYTOCERAS.				
Lytoceras cornucopiæ, *Young & Bird.*	...	*	...	...
hircinum, *Schlübler.*	...	...	*	...
Jurense, *Zieten.*	...	...	*	...
torulosum, *Schlübler*	...	...	*	...
Genus—PHYLLOCERAS.				
Phylloceras heterophyllum, *Sow.*	...	*	...	...
subcarinatum, *Young & Bird*	...	*	...	...
Family—AEGOCERATIDÆ.				
Genus—HARPOCERAS.				
Harpoceras serpentinum, *Reinecke.*	*	...	...	...
elegans, *Sow.*	*	...	...	...
falciferum, *Sow.*	*	...	...	...
exaratum, *Young & Bird.*	*	...	...	...
Lythense, *Young & Bird.*	...	*	...	...
latescens, *Simpson.*	...	*	...	...
ovatum, *Young & Bird.*	...	*	...	...
subplanatum, *Oppel.*	...	*	...	...
primordiale, *Schlotheim.*	...	*	...	...
bifrons, *Bruguiére*=Walcotti, *Sow.*	...	*	...	...
Levisoni, *Simpson.*	...	*	...	...
insigne, *Schübler.*	...	...	*	...
Comense, *Von Buch.*	...	...	*	...
discoides, *Zieten*	...	...	*	...
Thouarsense, *d'Orbig.*	...	...	*	...
striatulum, *Sow.*	...	...	*	...
radians, *Reinecke.*	...	...	*	...
Raquinianum, *d'Orbig*	...	...	*	...
undulatum, *Stahl*	...	...	*	...
variabile, *d'Orbig.*=var. Beanii	...	...	*	...
Aalense, *Zieten.*	...	...	*	*
opalinum, *Reinecke.*	...	...	...	*
Moorei, *Lycett.*	...	...	...	*
subinsigne, *Oppel.*	...	...	...	*
Genus—STEPHANOCERAS.				
Stephanoceras annulatum, *Sow.*	*	...	...	...
crassum, *Young & Bird*	*	*	...	...
Holandrei, *d'Orbig.*	*	*	...	...
commune, *Sow.*	...	*	...	...
fibulatum, *Sow.*	...	*	...	...
subarmatum, *Young & Bird*	...	*	...	...

Table showing the extension of the Upper Lias in the British Islands, Belgium, France, Switzerland, Germany, Austria, and Italy, with indications of the Toarcian Ammonite-Zones found in some typical regions of the European area.

Ammonite Zones of the Upper Lias.	British Islands.			Belgium.	France, Departments of.						Switzerland.		Germany.		Austria.	Italy.
	England.	Ireland.	Scotland.	Luxemburg.	Calvados.	Côte-d'Or.	Yonne.	Isère.	Rhône.	Aveyron.	Schaffhausen.	Aargau.	Hanover.	Württemberg.	N.-E. Alps.	Apennines.
OPALINUM	*	...	...	...	*	...	...	*	*	*	?	?	*	*	...	...
JURENSE	*	...	*	*	*	*	*	*	*	*	*	*	*	*	*	*
BIFRONS	*	...	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SERPENTINUM	*	...	...	*	*	*	*	*	*	*	*	*	*	*	*	*

This table concludes our sketch of the Lias formation, so rich in new and varied forms of animal life, which all became extinct with its close. In taking a retrospective glance at this chapter of the Geological Record, probably the most complete of all the Mesozoic formations, one is forcibly struck with the number of new, remarkable, and varied animal forms it contains, of which we find neither traces of ancestry nor natural affinities in any of the older strata. In its basement-bed the teeth of the oldest known Mammal, *Microlestes*, were discovered, and in its different horizons the remains of Reptiles of the most singular structure are found. The *Enaliosaurians* comprise in a single organism the most diverse anatomical characters; the vertebral column of a fish united to the body of a lizard, having the skull, jaws, and teeth of a crocodile, with the paddles of *Cetacea* articulated to the scapular arch of a *Platypus*. The *Pterodactylians* have affinities with birds and bats through the mechanism of their anterior extremities, the phalanges of the fifth finger being enlarged and elongated to form a rod for supporting a wide-spreading membranous wing, whilst the rest of the hand retained the reptilian type. The Ganoid Fishes belong to genera that are nearly all special to the Lias, and they are as remarkable for the beauty and novelty of their forms as for the fine state of preservation in which they are found. The Molluscan Faunas are singularly characteristic of the different zones; and the Cephalopods, above all others, are the most important class, from the certainty with which these divisions of time are characterised by them, each new group making its appearance in succession, and passing away to give place to other generic forms destined to succeed it in time and space.

PLATE IX.

Zone of Arietites Bucklandi.

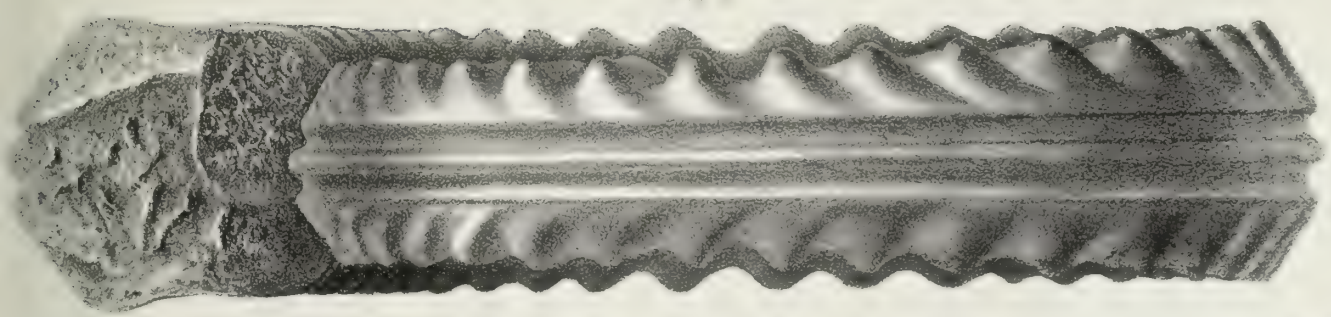
Fig. 1. Arietites rotiformis, *Sowerby*. Lateral view of a fine specimen, natural size, with the shell preserved, from the Lower Lias de l'Auxois, Semur, Côte-d'Or; kindly given me by Monsieur J. J. Collenot, of Semur, to illustrate this work.

2. Front view of the same specimen, natural size, to show the siphonal area and depth of the bisulcations, with the spine-like character of the tubercles.

3. An accurate outline of the foliations of the septa magnified.

Fig 1

Fig 2



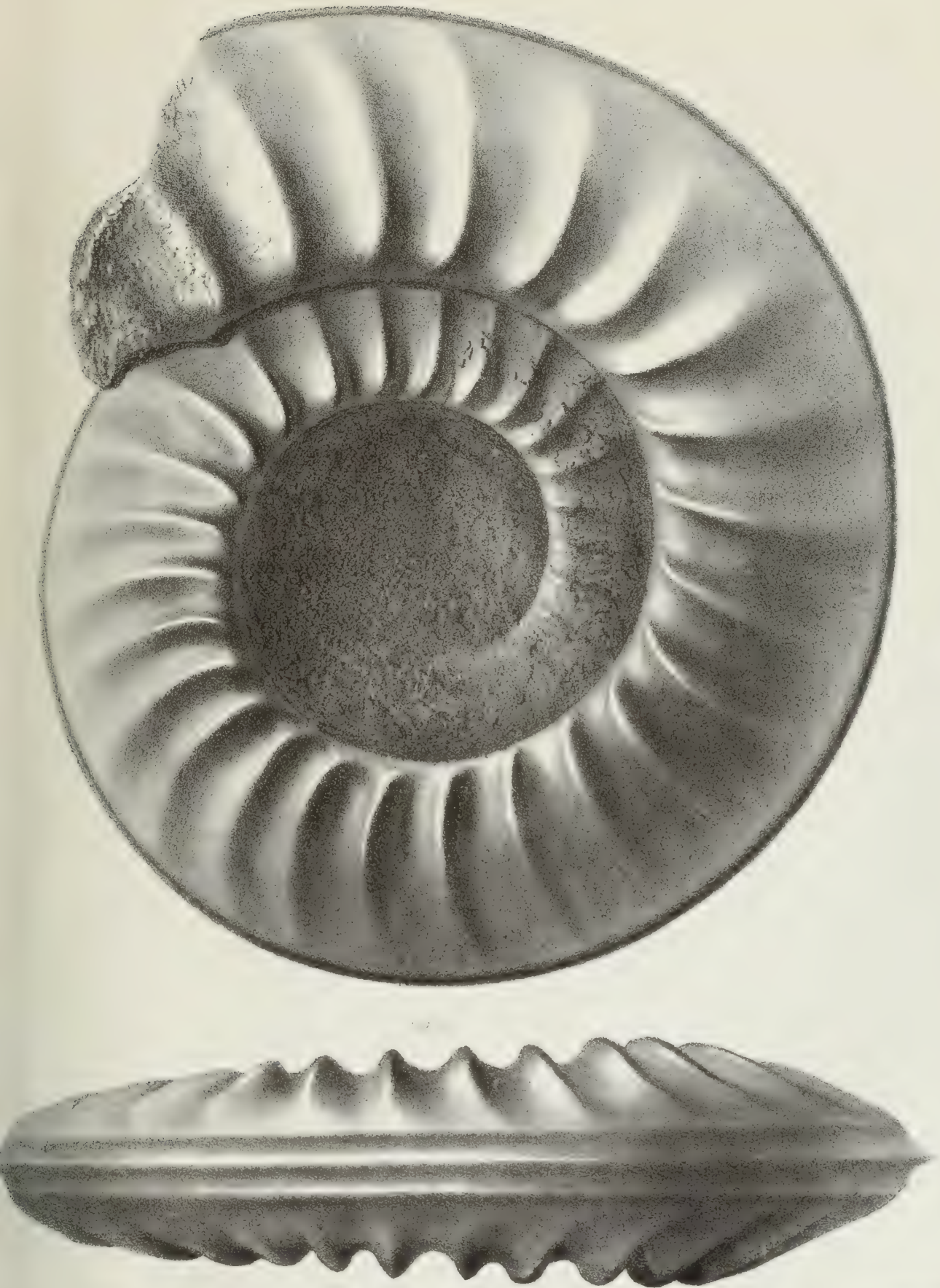
Gawan lith

PLATE X.

Zone of Arietites Bucklandi.

Fig. 1. Arietites Crossii, *Wright.* Lateral view, half the natural size, from the Scunthorpe Ironstone, North-west Lincolnshire, remarkable for the great development of the ribs near the line of involution, from the collection of the Rev. J. E. Cross, F.G.S., Appleby, Brigg, Lincolnshire.

2. Back view of the same fossil to show the narrow siphonal area, sharp narrow keel, shallow bisulcations, and trenchant ribs.



van hth

Hanhart imp

PLATE XI.

Zone of Arietites Turneri.

Fig. 1. Arietites Bonnardii, *d'Orbigny*. Lateral view, natural size, from Lyme Regis, in my collection.

2. Back view of the siphonal area, showing the oblique rib terminations.

3. Front view do. do. do.

Zone of Aegoceras Jamesoni.

4. Aegoceras Jamesoni, *Sowerby*. Lateral view, natural size of a good type form of this rare species; the specimen was collected at Hechingen, Württemberg.

5. Back view of siphonal area of the same fossil, showing the rib arches.

6. Front view do. do. do. My collection.

Fig 2

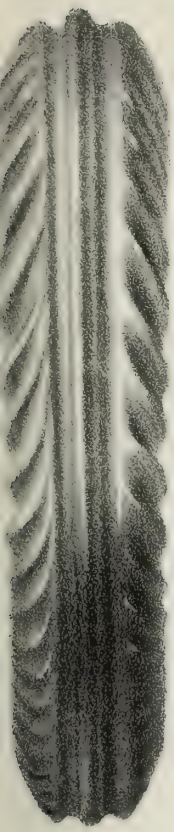


Fig 1

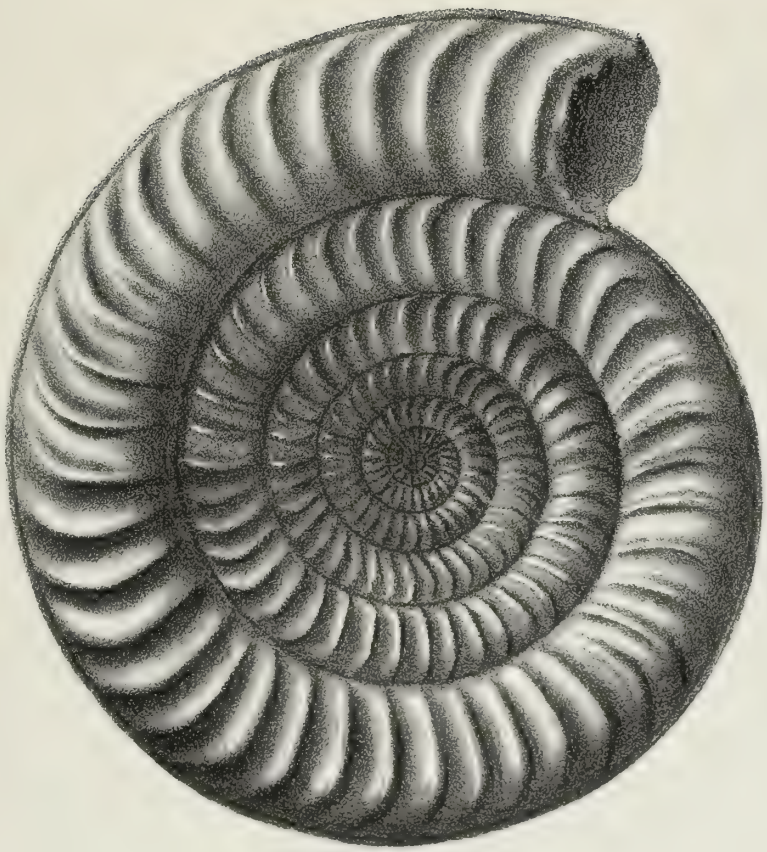


Fig 3

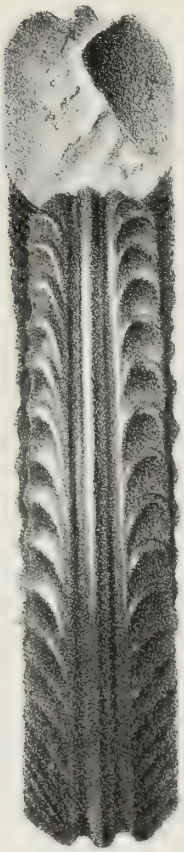


Fig 5

Fig 4

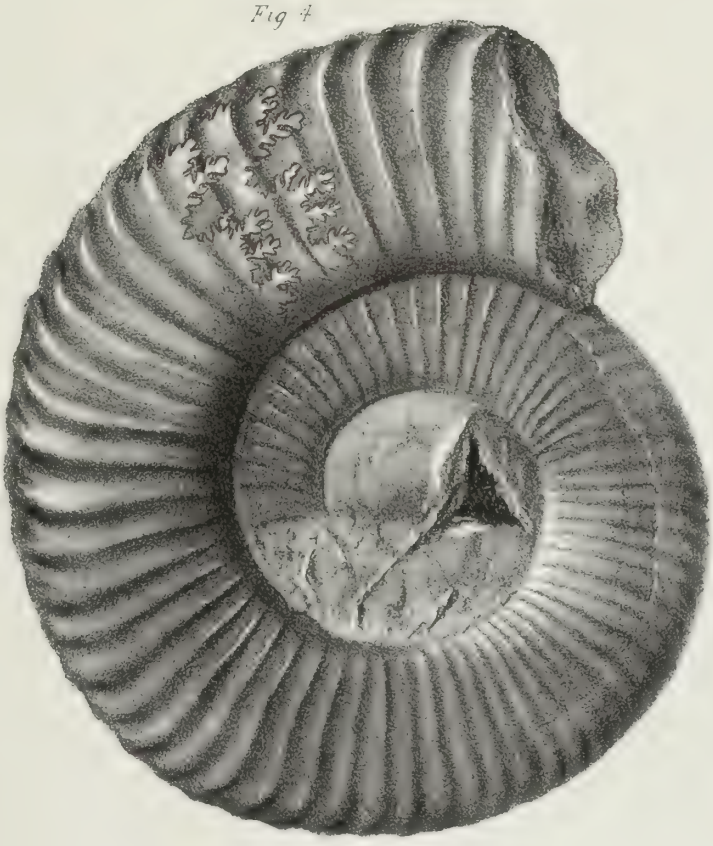


Fig 6.

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Hanhart imp

PLATE XII.

Zone of Arietites Turneri.

Fig. 1. Arietites Turneri, *Sowerby.* Lateral view, natural size, from Bredon, Worcestershire, obtained in cutting the Midland Railway. My collection.

2. Front view of siphonal area and line of dorsal suture.
3. Back view do. do.
4. Lateral view of one of Sowerby's type specimens in the British Museum, figured as a good example for comparison.
5. Accurate outline of lateral lobes and saddles, enlarged.
6. Do. do. of dorsal lobes and saddles, do.

Fig 1

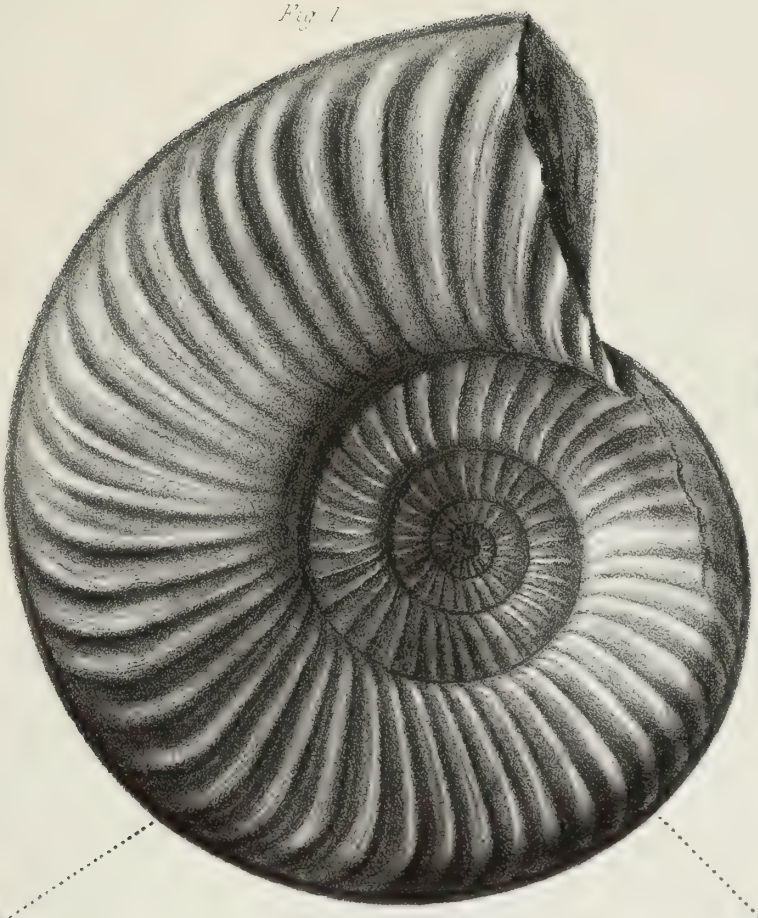


Fig 2

Fig 3

Fig 4

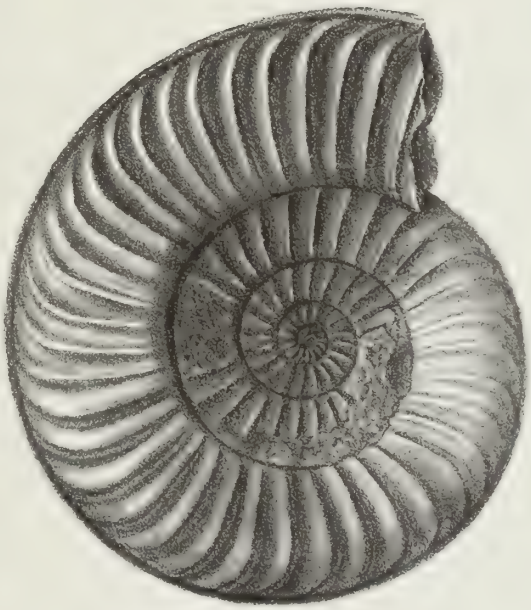
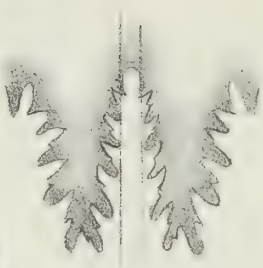


Fig 5

Fig 6



awan lith

Hanhart imp

PLATE XIII.

Zone of Arietites Bucklandi.

Fig. 1. Arietites Scipionianus, *d'Orbigny*. Lateral view, natural size, Semur, Côte d'Or.

2. — — — Front view of siphonal area.

3. Accurate outline of the dorsal and lateral lobes and saddles, enlarged.

Fig 1

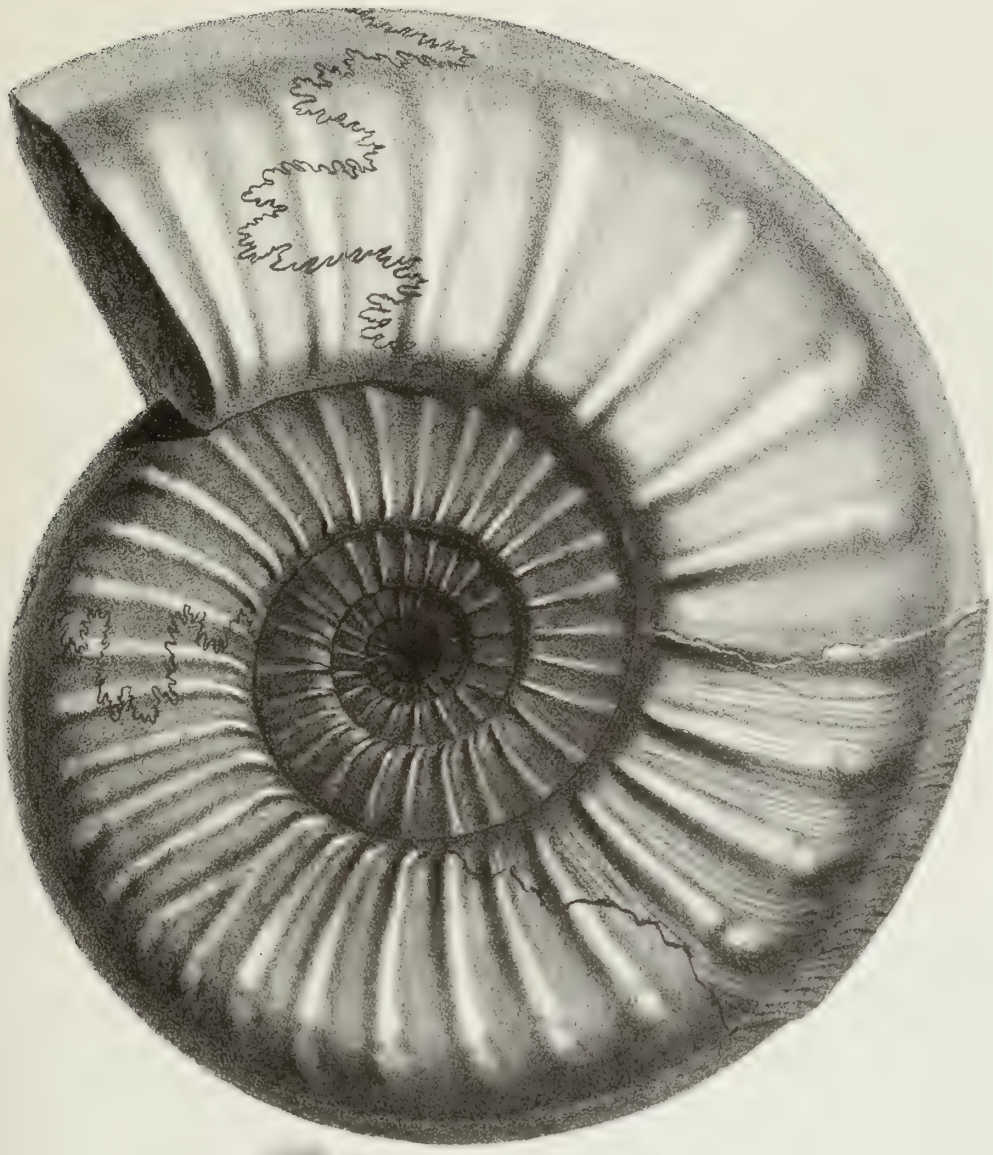


Fig 2

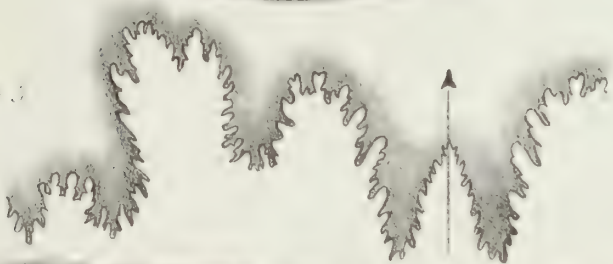


Fig 3

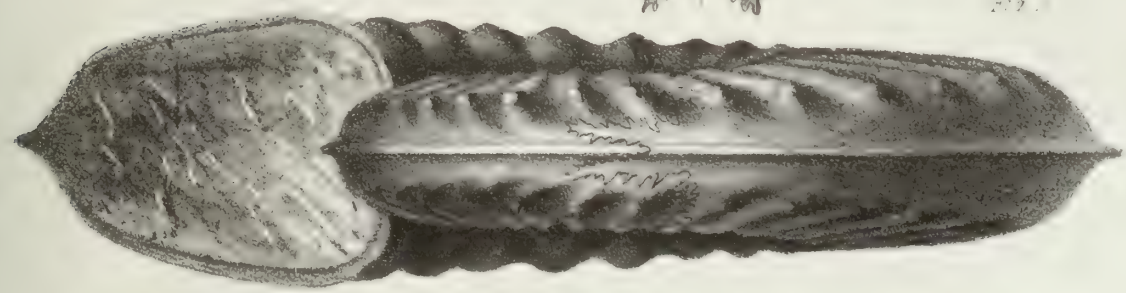


PLATE XIV.

Zone of Aegoceras planorbis.

Fig. 1. AEGOCERAS PLANORBIS, *Sowerby*. Side view, natural size, from Lower Lias, Robin Hood's Bay. Woodwardian Museum, Cambridge. Leckenby Collection.

2. Front view, natural size, of the same specimen.

3. Lateral view of *Aegoceras planorbis*, from the Lower Lias of Württemberg, with the *Aptychus* and *oral aperture* contraction, drawn by Dr. W. Waagen, "Ueber die Ansatzstelle der Haftmuskeln beim Nautilus und den Ammoniden," 'Palæontographica,' Band xvii, T. xl.

4. Accurate outline of the dorsal and lateral lobes and saddles, enlarged.

Zone of Aegoceras angulatum.

5. AEGOCERAS ANGULATUM, *Schlotheim*. Lateral view, natural size. Lyme Regis. My collection.

6. Siphonal area showing the flexure of the ribs and angles they describe.

Fig 3

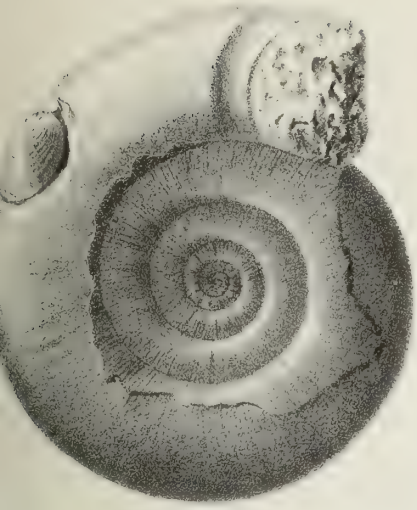
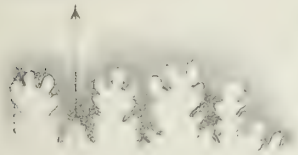
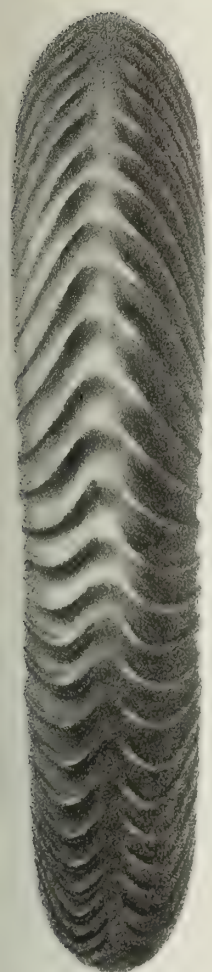


Fig 2

Fig 1

Fig 4





van lith.

Hannart imp

PLATE XV.

Zone of Aegoceras angulatum.

Fig. 1. AEGOCERAS LIASSICUM, *d'Orbigny*. A fragment from the Trent Valley, Lincolnshire. Rev. J. E. Cross, F.G.S., Appleby, Brigg, Lincolnshire.

2. — — — Side view of the same, natural size.

3. AEGOCERAS INTERMEDIUM, *Portlock*. Side view, natural size. Museum of the Irish Geological Survey. One of General Portlock's type specimens.

4. — — — Siphonal area of the same fossil.

5. — — — Side view of a large specimen from the same collection.

6. — — — Siphonal area of the same shell.

7. AEGOCERAS BELCHERI, *Simpson*. Side view, natural size. Lower Lias, Robin Hood's Bay. Woodwardian Museum, Cambridge. Leckenby collection.

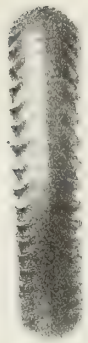
8. — — — Siphonal area of the same fossil.

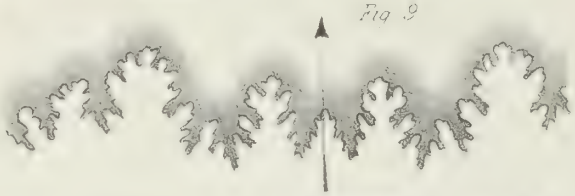
9. — — — Lobes and saddles of same highly magnified.

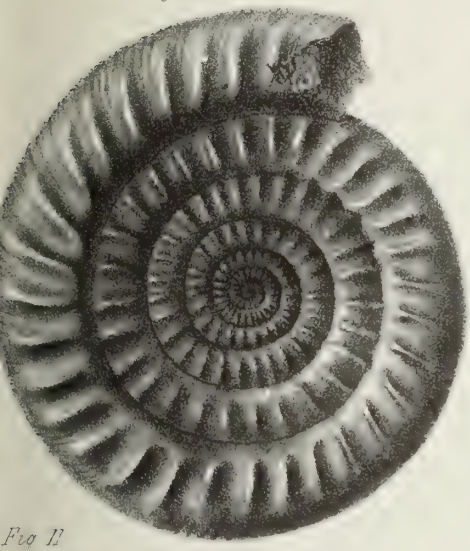
10. AEGOCERAS TORTILE, *d'Orbigny*. Side view, natural size. Sent me by Monsieur A. Etallon. Collected in the Lower Lias, France.

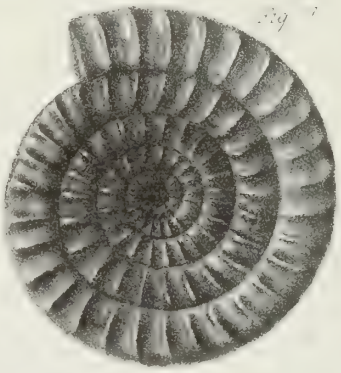
11. — — — Siphonal area and dorsal lobes of same.

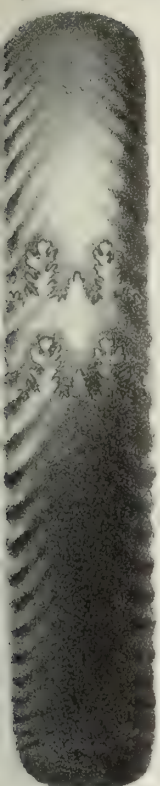
12. — — — Front view of siphonal area.

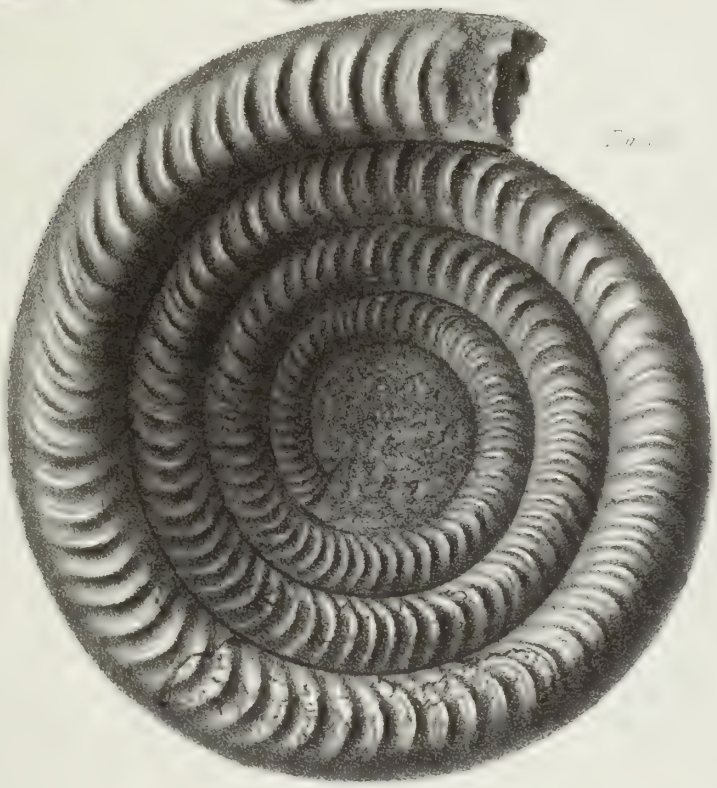












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Hanhart imp

PLATE XVI.

Zone of Aegoceras angulatum.

Fig. 1. Aegoceras Liassicum, *d'Orbigny.* Side view, natural size. Lower Lias, Redcar, Yorkshire. My collection. Procured at Whitby.

2. — — — Siphonal area of the same fossil to show the absence of the ribs in this region.

This specimen resembles two large examples of this species contained in the d'Orbignian type collection in the "Jardin des Plantes," Paris.

Fig. 1.

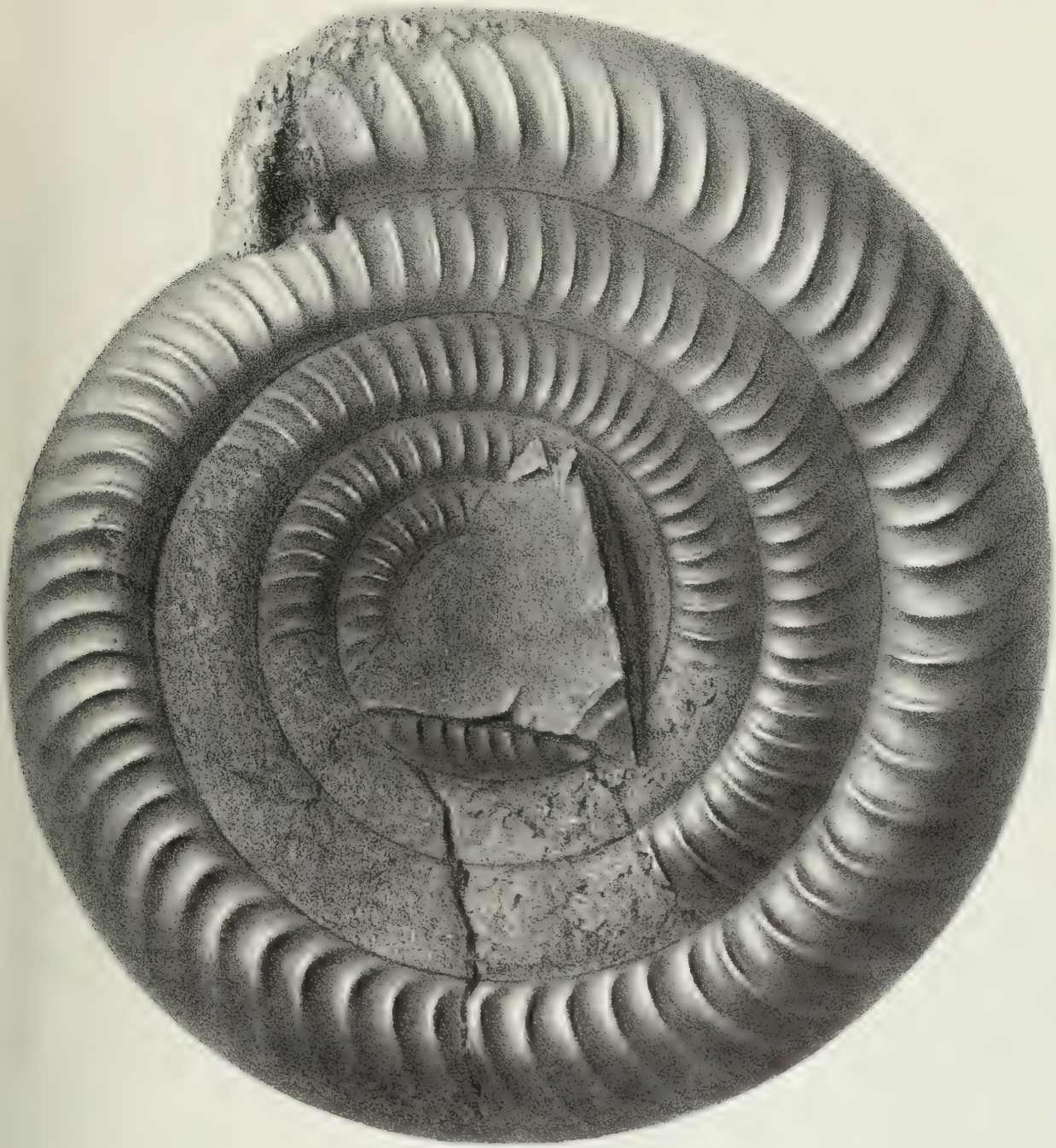
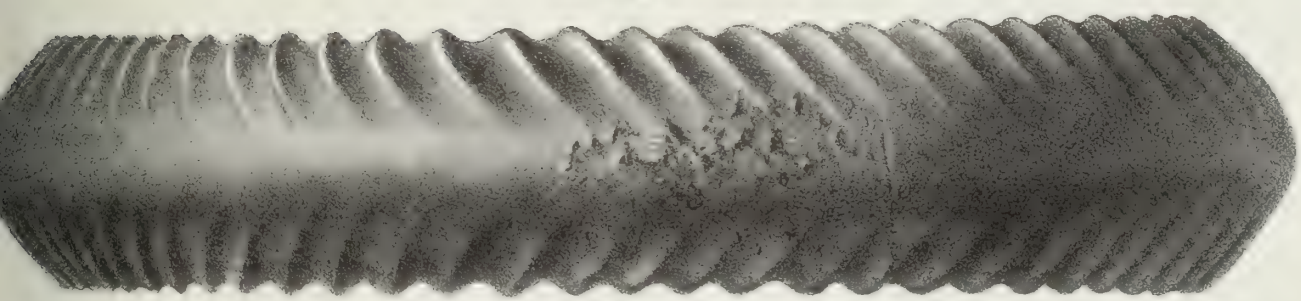


Fig. 2.



Dawan lith

PLATE XVII.

Zone of Aegoceras angulatum.

Fig. 1. AEGOCERAS ANGULATUM, *Schlotheim* = AMMONITES MOREANUS, *d'Orbigny*. Side view, natural size. Lyme Regis. My collection.

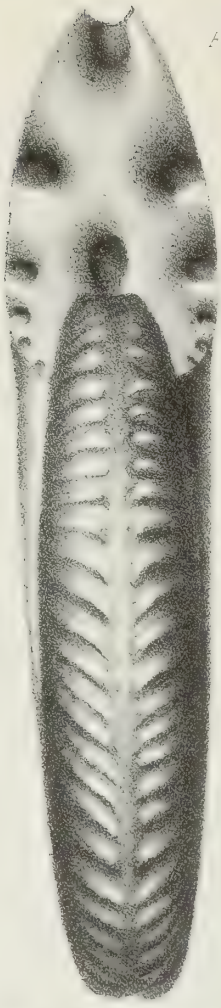
2. — — — Front view of the siphonal area of the same fossil showing the rib terminations.

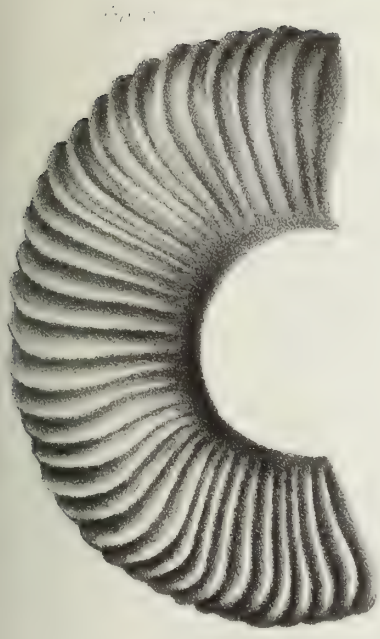
3. — — — Lateral view of ribbing in another specimen from the same bed.

4. — — — Continuous ribbing over the siphonal area in the same specimen.

5. — — — Smaller and closer ribbed variety from the same bed, natural size.

6. — — — Siphonal area with interrupted ribbing, forming angles in the same.





Mary Suft. del. et lith

PLATE XVIII.

Zone of Arietites Bucklandi.

Fig. 1. AEGOCERAS BOUCAULTIANUM, *d'Orbigny.* Lateral view, natural size, from the Upper Bucklandi beds of the Scunthorpe ironstone, North-West Lincolnshire, collected by the Rev. J. E. Cross, F.G.S., to whose collection this unique specimen belongs.

2. — — — This figure represents the shell reduced to one third the natural size, from a specimen in the collection of Monsieur Boucault, of Semur. I have seen specimens of this species in the Semur Museum with the shell preserved which measured from twelve to fifteen inches in diameter.

3. — — — Front view of the same shell to show the auxiliary lobes, depressions, and ornamentation on the margins of the siphonal area.

4. — — — A portion of the foliations of the septa drawn by the late Prof. Alcide d'Orbigny, the size of nature.

Fig 1

Fig 2

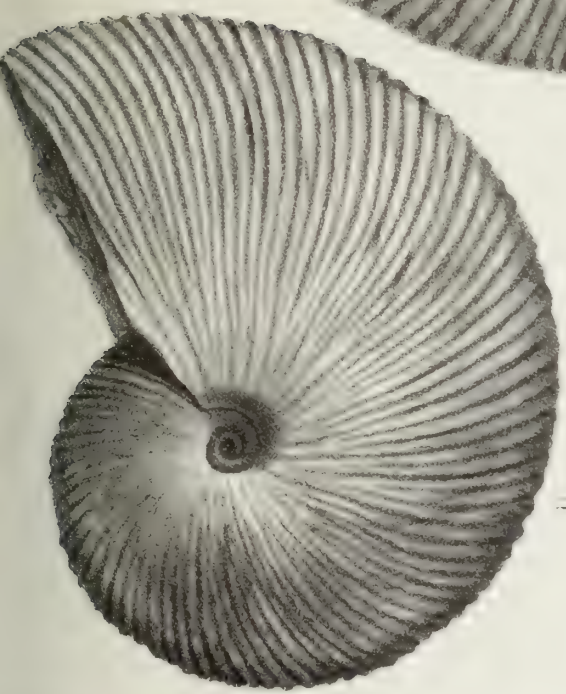


Fig 4

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MDCCCLXXIX.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

SUPPLEMENT No. IX.

PAGES 1—19; PLATES I—IV.

CROCODILIA

(GONIOPHOLIS, BRACHYDECTES, NANNOSUCHUS, THERIOSUCHUS, AND NUTHETES).

BY

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FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE,

ETC. ETC.

Issued in the Volume for the year 1879.

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SUPPLEMENT (No. IX)

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE WEALDEN AND PURBECK FORMATIONS.

(GONIOPHOLIS, BRACHYDECTES, NANNOSUCHUS, THERIOSUCHUS, AND NUTHETES.)

Order. *CROCODILIA.*

The subjects of the present 'Supplement' are from the same division ('Featherbed') of the fresh-water deposits of the Middle Purbeck series as the Mammalian fossils described in the under-mentioned volume,[1] and were disinterred by the skilful and enterprising explorer of that geological series, Samuel Husband Beckles, Esq., F.R.S., to whom the discovery of most of those fossils is due.

The whole of Mr. Beckles' gatherings from the Purbeck shales having been acquired by the British Museum, many slabs with indications of organic remains have been carefully worked out, and the chief parts of the subjects of Plates I—IV have thus been brought to light.

At the first aspect, detecting in the scattered groups of scutes specimens showing the peg (Pl. IV, fig. 3, *a*) and groove (ib., fig. 4, *b*), it seemed as if remains of some young specimens of *Goniopholis* were so exposed. The condition, however, of two of the skulls (Pl. III, figs. 1 and 3) enabled a comparison to be made which determined their specific and, by their dentition, generic distinctions from both *Goniopholis* and *Petrosuchus*. The number of maxillary and mandibular specimens, of which several are figured in Pl. III, exemplified a degree of constancy in size which begat a conviction that such was a character of the species; and, diminutive as were the Reptilia which have supplied the subjects of both plates, their characters were indisputably those of the Order *Crocodilia*. One of them, by the size and shape of certain teeth, came nearer to *Goniopholis*, another

[1] 'Monograph of the Fossil Mammalia of the Mesozoic Formations;' in the Volume of the Palæontographical Society for the year 1870.

by the same character resembled *Petrosuchus*, but the differential characters were such as could not have been obliterated by growth or age.

A third form of Crocodilian made a nearer approach in one of the species (Pl. I, fig. 2) to the average size of the broad-faced genera. A fourth (ib., fig. 1) corresponded in size with the subject of fig. 2, but offered no character by which it could be legitimately removed from the genus *Goniopholis*. I commence with the description of this small but well-marked species.

Genus—GONIOPHOLIS, *Owen*.[1]

Species—*Goniopholis tenuidens*. Plate I, fig. 1.

The dental character of the Amphicœlian genus *Goniopholis* consists of the numerous close-set, fine, longitudinal ridges of the enamel, two of which, larger and sharper than the rest, traverse opposite sides of the tooth from the base to the apex of the crown, midway between the convex and concave lines of the curvature of the tooth, that is, at the fore and back parts of the crown.[2]

The general shape and proportions of the tooth-crowns indicate distinctions of species of *Goniopholis*. The type of the genus is characterised by the thickness and subcircular section of the crown, and the obtuseness of that in the posterior teeth.[3]

In *Goniopholis simus*[4] the proportion of breadth to length of crown is less than in *G. crassidens*, and this difference is more marked in the specimen from the Feather-bed of Purbeck which forms the subject of fig. 1, Pl. I.

This specimen consists of the chief part of the dentary and co-articulated splenial elements of both rami of the same mandible, partially dislocated at the symphysis. The alveolar tract includes the incisive (*i*) and molary (*m*) convexities, without an intervening laniary rising. The incisive convexity includes five sockets, a tooth being retained in the first, third, and fourth on the right, and in the first and third sockets on the left dentary. The foremost tooth has a crown of 6 mm. length and barely 2 mm. of basal breath; each has partially emerged from a socket larger than itself, and exhibits a portion of a tooth in succession to one which has been lost or shed. The socket is separated by an interval of 2 mm. from the second. This shows a subcircular aperture of 5 mm. in diameter. The third socket opens at 2 mm. distance from the second. The tooth (*i*) in the right dentary shows the inner, longitudinally concave side of the crown, with a basal breadth of 6 mm.

[1] 'Reports of the British Association,' 8vo., 1841, "On British Fossil Reptiles," part ii, 1841, p. 690.

[2] Loc. cit., pp. 69, 70.

[3] 'Supplement (No. viii) to the Monograph on the Fossil Reptilia of the Wealden and Purbeck Formations,' Palæontographical Volume for the year 1878, p. 1, pl. i, fig. 7.

[4] Ib. Ib., p. 7, pl. v.

and a total length of 16 mm. One may count about a dozen fine longitudinal linear ridges between the fore and hind stronger ones (ib., fig. 1 *b* and *b'*, magn.). The corresponding tooth (ib., fig. 1 *a*, magn.) in the left dentary shows the outer longitudinally convex side of the crown, with about sixteen fine ridges. These teeth answer to, or interlock with, the premaxillary or anterior canines of the upper jaw. The fourth tooth (ib. *c*) is less than the third; its crown projects 10 mm. from the right dentary; the fractured base of the corresponding tooth in the left dentary is 4 mm. in diameter. Seven close-set sockets follow along the feebly concave part of the alveolar tract. The tooth of the twelfth socket at the beginning of the second convexity is preserved in both rami; its crown is 8 mm. in length, 4 mm. in basal breadth, with an obtuse summit, showing the feeblest indication of an apical point. This point is rather better seen in the crown of the next tooth, which has not wholly emerged.

The total number of teeth is sixteen in each of the dentary elements here preserved, and by analogy to the *Goniopholis simus*,[1] the whole, or nearly the whole, of the dental series or sockets, in one dentary element is here exhibited.

The outer surface of the dentary is pitted by small subcircular, not close-set, impressions, except on the outer alveolar plate of the molary rising, where a few longitudinal pits indent the otherwise smooth surface of the bone.

The length of the symphysis is 25 mm., the depth 10 mm. The extreme breadth of the incisive part of the mandible is 32 mm.

The length of the preserved alveolar part of the dentary is 85 mm. (3 inches, 3 lines); the length of the entire mandible might have been between 5 and 6 inches.

Fragmentary evidences of the *Goniopholis tenuidens* in other slabs of matrix do not indicate any individual of a larger size than is exemplified by the above-described portion of lower jaw.

The mandible of *Goniopholis crassidens*, with an extreme depth of 4 inches, attained the length of 2 feet. Of this length the alveolar part of the dentary element occupied, as in most broad-faced Crocodiles, one half. The length of the alveolar part of the mandible of *Goniopholis tenuidens* being 3 inches, the total length of the jaw may be set down at one fourth of that of the type species of the genus.

Genus—BRACHYDECTES, *Owen*.[2]

Species—*Brachydectes major*. Plate I, fig. 2.

In this genus and species a left mandibular ramus, 9 inches 6 lines in length, shows an alveolar tract of but 3 inches 9 lines in length. In the proportion of the jaw, therefore, appropriated to the lodgment of the teeth this Crocodile differs from the rest of the

[1] 'Supplement' (No. viii), *ut supra*, p. 8.

[2] Gr. βραχὺς, short; δηκτὴς, biter.

family. The ramus has a less relative depth than in *Brachydectes minor*, fig. 3; it measures in extreme vertical extent, taken at about one fourth of the length from the angle, 1 inch 9 lines, or little more than one sixth the entire length of the ramus, whilst in *Br. minor* the extreme depth of the mandible, which is about midway between the two ends, is nearly one fifth of the entire length of the ramus. This proportion might, however, be deemed an immature character of the smaller specimen, but there are other differences in the jaw of *Brachydectes major* not attributable to age and consequent growth. There is no longitudinal ridge on the angular element. The angle itself is more produced. This process repeats, indeed, the low position characteristic of the genus *Brachydectes*, but the line descending thereto from the articular element is straight, not concave, as in *Br. minor*, and the curve from the angle to the convex border of the angular element (fig. 1, 30) is deeply concave. Moreover, the outer surface of the deep hinder part of the ramus is sculptured with close-set deep pits, giving a strongly reticular character to that part of the bone.

The alveolar tract shows, as in *Brachydectes minor*, a laniary convexity (*l*) as well as an incisive one (*i*); both, however, are slight. In the latter the crown of the third or fourth incisor is preserved; it is 20 mm. in length, 6 mm. in basal breadth. The enamel of the exposed outer side is smooth; the fore part of the crown is obtuse, the hind part trenchant, with a faint appearance of minute denticulation. This is the only tooth preserved in the present jaw. There are faint indications of ten or twelve alveoli behind the tooth; two of these in the laniary curve (*l*) indicate teeth proportionally as large as the canine in *Brachydectes minor*. The outer surface of the laniary convexity is smooth. The rugged irregularly and minutely pitted character is continued to the alveolar border of the incisive convexity. The sutures between the dentary and hinder elements of the mandible are not clearly definable. Certain parts of the outer surface which were wanting made it doubtful whether any vacuity between the surangular, angular, and dentary elements existed; and the condition of the jaw of the smaller species weighs in favour of assigning an uninterrupted outer wall of the mandible as an additional differential character of the genus.

The proportion of the incisor tooth approaches that of the third in *Petrosuchus*,[1] but the latter is longer in proportion to the basal breadth. The dental series, and consequently the dentary element, are relatively longer in *Petrosuchus* than in *Brachydectes*.

A second specimen of the left dentary bone repeats closely the same size and characters of the corresponding part of the mandibular ramus above described. The teeth are wanting. Behind the alveolus of the 'anterior canine' are indications of seven or eight following alveoli, not more. The better preserved outer plate of the bone demonstrates the absence of the vacuity which is present in *Petrosuchus*, *Goniopholis*, and *Crocodilia* generally.

[1] 'Supplement' (No. viii), pl. vi, fig. 3.

Species—*Brachydectes minor*. Plate I, fig. 3.

This species first indicated the genus in the exploratory operations; it is represented by the left mandibular ramus (Plate I, fig. 3), which is remarkable, as in the larger species, for the small proportion which the alveolar tract bears to the entire length of the bone, and for the entireness of the outer wall. The alveolar tract is undulated, showing an incisive and a laniary convexity with intervening and hinder concavities.

The incisive convexity holds five teeth, close set, the two hindmost rather larger than the rest; but no single tooth is so much larger as to suggest the name of 'canine.' The laniary convexity shows one large canine with a broad, straight, laterally compressed crown. It is preceded by a smaller tooth, rather less than the hindmost incisor, and separated therefrom by a space which may have held two or three small teeth. The alveolar tract behind the canine seems to have lodged three or four teeth, the crowns of which are lost.

The whole length of the alveolar tract is 23 mm. (1 inch); that of the entire ramus is 85 mm. (3 inches 2 lines). The dentary element bifurcates behind as usual; the upper prong joining the surangular, the lower and longer one the angular, but without defining or leaving any vacuity; the union where such vacuity would have been left in ordinary Crocodiles is situated well within the anterior half of the ramus. The posterior elements are correspondingly of unusual length; their breadth is also proportionally greater than in previously known Crocodilian mandibles. The length of the surangular element (29′) is 48 mm. (1 inch 10 lines); its depth (vertical breadth) is 13 mm. (6 lines). The upper border describes a feeble convexity; beneath the articular surface of 29 the surangular curves downward and backward, meeting the lower border at a point wedged between the articular and angular elements.

The articular exposes the outer antero-posterior concave border of the joint. From this it descends obliquely backward and joins the angular in forming the process (30′), which here projects directly backward, its termination being much below the joint, and nearly on the level of the lowest part of the lower border of the jaw. The angular element extends forward from the angle, with its lower border at first straight or feebly concave, and then moderately convex to its junction with the dentary; a ridge projects along the greater part of this course a little way above the lower border. A portion of the splenial element shows above the fore part of the surangular, and supplements the inner alveolar wall at the hind part of the dentary.

From the lower jaw of *Theriosuchus* (Plate III, figs. 5, 14, 16) the present differs in the shortness of the dentary element and alveolar series, in the greater depth and verticality of the outer surface of the ramus, and the narrower inferior border. It also offers a generic distinction in the number and shape of the teeth.

The proportional length and slenderness of the dentary and the absence of any

laniary convexity succeeding the incisive one, together with greater number and the shape of the teeth of *Nannosuchus* (Pl. II, figs. 8 and 9) offer a more striking contrast with the mandible and teeth of *Brachydects.*

No specimens have been brought to light which show characters of *Brachydectes minor* on a larger scale than is represented by the mandibular ramus above described.

Genus—NANNOSUCHUS,[1] *Owen.*

Species—*Nannosuchus gracilidens.* Plate II, figs. 1—10; Plate III, figs. 1 and 2.

In this genus the teeth have long, slender, sharp-pointed crowns, slightly recurved, mostly sub-circular in transverse section, impressed by a few linear or narrow and shallow grooves. The dental series is pretty uniform as to size and shape of crown, but less so than in the Teleosaur and Gavial; the teeth are also less numerous and wider apart.

The claim to generic distinction indicated by the armature of both upper and lower jaws was established by an additional dental character revealed in the following specimen.

The fore part of the mandible (Plate II, fig. 1) exhibited a tooth *in sitú* (fig. 1 *c* and fig. 2 enlarged), answering to that termed the 'anterior canine' in *Crocodilia,* but presenting characters which I had not before observed in those or other *Reptilia.*

The crown is long in proportion to the basal breadth, conical, recurved, and pointed. It is traversed along the middle of the outer surface by a ridge, or rather a low angle of the enamel, simulating a ridge; between this and the trenchant hind border is included one third of the outer surface of the crown. This tract is smooth, and, transversely, is feebly depressed or concave, giving a trenchant character to the hinder longitudinally concave edge of the crown. The two thirds of the outer, transversely convex, surface of the crown is traversed by close-set linear grooves, and intervening ridges, which mostly subside at the apical half of the crown, leaving about one third of the apex smooth. This tooth appears to be the fourth counting backward; the length of the crown is 10 mm., the basal breadth 3 mm. An enlarged view is given of the outer side of the crown in fig. 2.

The foremost tooth, also preserved (fig. 1, *i*), shows a coronal length of 5 mm., a basal breadth of 1 mm.

The crown of a fifth tooth rises close behind that of the fourth, with a basal breadth of 2 mm, and a length of 5 mm.; it is conical, but is straight. The outer side, uniformly convex, is traversed along the basal half by fine ridges and intervening grooves; it may be that the whole of this crown has not emerged.

[1] *νάννοι*, dwarfish, Σοῦχυς, an Egyptian name of the Crocodile.

The portions of mandible, the subject of fig. 1, consist of the right and left dentary elements, of which the major part is preserved, the rest indicated by impressions on the matrix. The preserved parts include the symphysial expansion, the joint being slightly dislocated through pressure, which has acted obliquely. The right dentary shows its outer side, the left dentary its lower border, and beyond the symphysis a small proportion of the outer surface, while the inner one is partly covered by the smooth splenial element (31).

The breadth of the symphysial part of the right dentary is 15 mm.; the length of the under part of the symphysis is 18 mm. At 33 mm. from the fore end the (vertical) breadth of the ramus diminishes to 10 mm., beyond which it gradually increases to 15 mm., where the bifurcation of the bone begins. The entire length of the part preserved is 114 mm. (nearly $4\frac{1}{2}$ inches).

The exterior of the symphysial part of the dentary is pitted by numerous minute subcircular depressions. As the bone contracts the depressions enlarge and elongate, then take the form of longitudinal grooves of irregular depth; but these become limited to the lower half of the outer side of the dentary, the part above, which forms the outer alveolar plate, being smooth, with a few faint, short, longitudinal linear impressions.

The symphysial expanse of the right dentary shows five sockets, of which, as above stated, the first, fourth, and fifth retain their teeth. The implantation of these teeth in complete sockets confirms the indication by the sculpturing of the bone that the jaw has belonged to a member of the Crocodilian order.

The first tooth was the smallest; the second and third, judging from the sockets, gained in size; the fourth is the largest, and represents, as above remarked, the tooth opposing or interlocking with the premaxillary canine above; the fifth abruptly loses size. Of the succeeding teeth little more can be divined from the present specimen than that they were small or, at least, slender. The convex curve, lengthwise, of the outer alveolar border is very feeble, and seems to have helped to lodge the hinder teeth; it is divided by a long feeble concavity from the symphysial or incisive convexity. There is no laniary rising.

Two smooth bones (31, *x*) contribute to the inner wall of the ramus, as exposed on the left side. If the lower one (*x*) represents the splenial, the upper one (31) would be an unusually developed inner plate of the dentary. If this, however, should be, as its posterior expansion indicates, according to the analogy of the modern Crocodiles, the splenial element (31), then the lower bone (*x*), would represent an angular element unusually produced forward. The longitudinal line of demarcation between these smooth inner questionable elements is not an accidental crack.

The Crocodilian character of the present jaw is supported by the scutes (Pl. II, fig. 4) and impressions (fig. 5) of scutes, by a vertebra (fig. 3), portions of ribs with a bifurcate proximal end, and by a metacarpal bone, all on the same slab of matrix.

The vertebra is Amphicœlian; the neurapophysial suture is unobliterated; it is from the part of the trunk where the rib articulation has risen wholly above the centrum. This element is 13 mm. in length; the non-articular surface is smooth and entire, gradually and slightly expanding to the articular ends; the one exposed being subcircular, 10 mm. in diameter.

Of the scutes preserved the largest are oblong, quadrangular, with a tooth-like process from the anterior and outer angle, from the base of which is continued a raised smooth tract along the anterior border, from 4 to 3 mm. in breadth. The breadth of the entire scute is 17 mm.; the length is 35 mm. Some smaller scutes are pentagonal.

We have here, therefore, evidence of an Amphicœlian Crocodile, with the dermal armour after the type of that of *Goniopholis*, but generically distinct by the characters of the mandibular dentition. If the dentary bone constituted three fourths the length of the mandible this may be reckoned to have been about 6 inches in length, and the entire Crocodile may have been 6 feet in length.

The portion of mandible of which the under surface of the dentary and splenial elements are exposed, forming the subject of fig. 6, Plate II, is shown by certain teeth in place and others scattered near in the same slab, to belong to the same genus and species as that represented by fig. 1, and to have come from an individual of similar size. Both are the largest evidences of *Nannosuchus* shown in the numerous series of Reptilian fossils from the portions of the 'Feather-bed' formation now under review.

The symphysis, 21 mm. in longitudinal extent, forms a fifth part of the preserved extent of the dentary; the breadth of this part of the jaw is 30 mm.; that behind the symphysis is 27 mm. The rami, as far as they are preserved, diverge to a breadth of 70 mm.

The alveolar part of the symphysis describes an incisive convexity, and the sockets indicate one or two teeth of larger size and thicker proportions than those of the rest of the dental series. The crowns of two of these teeth, which had become detached, are fortunately preserved, near the fore part of the jaw. The largest (fig. 7, magn.) represents the 'anterior canine,' and is the homologue of fig. 1 *c* and fig. 2, magn. It shows the well-marked characteristics of that tooth in *Nannosuchus*, and, besides the difference of sculpturing, the crown is more strongly curved than in *Goniopholis* or *Petrosuchus*. The second detached tooth near the incisive alveoli shows both root and crown. The latter is but half the length of that of the 'canine;' more of the convex side is exposed than in fig. 2; it is traversed by fine longitudinal ridges. The teeth which are in place show a smaller size and more slender pointed crown. There is no evidence of any tooth equalling in size the largest of the symphysial or incisive series.

The numerous minute circular pits sculpturing the symphysial expansion change, as in the specimen (fig. 1), to coarser and larger longitudinal impressions as the rami recede and pass backward; and the surface near the alveolar border showing the feeble molary convex curve is smooth.

The dental character of *Nannosuchus* is more fully exemplified by smaller specimens, of which two, forming parts of the lower jaw, will be first noticed.

The subject of fig. 8, Pl. II, includes the dentary and angular elements, partially dislocated, of the right mandibular ramus. Two of the molary series of teeth are *in sitû*, showing long, slender, feebly recurved crowns, each 5 mm. in length; other teeth of similar shape and with finely striate enamel are on the same slab.

In a smaller dentary (Pl. II, fig. 9) the sockets of eighteen teeth are visible. The proportions and outer markings agree with those of the larger specimen.

The humerus (fig. 10), preserved near the jaw, shows the usual Crocodilian characters, with more slender proportions than in *Crocodilus niger;* it rather resembles that of the Gavial.[1]

The characters of *Nannosuchus* yielded by the foregoing specimens are supplemented by those of the skull represented of the natural size in Pl. III, fig. 1. The teeth preserved *in sitû* and detached, but in contiguity with the alveolar border, are generically those to which they would be opposed assuming the skull to be that of a *Nannosuchus*. The inferiority of size is not shown by any other distinctive character to indicate a species other than that founded on the lower jaws above described.

As in those, the teeth of the upper jaw are divided by intervals usually greater than their basal breadth. Each premaxillary (fig. 1, 22) had four teeth at least; the maxillary had not fewer than ten teeth.

The characters of length and slenderness of crown in the teeth of this small Crocodile suggested a comparison of its skull with that of *Petrosuchus*,[2] but the differential characters exceed in importance those of size. The upper jaw of *Nannosuchus* does not contract so rapidly, or in so great a degree in advance of the orbits, as in *Petrosuchus;* it is also shorter as well as broader; no amount of growth could have converted it into the slender elongate shape which approximates *Petrosuchus* to the gavial-like *Crocodilus cataphractus*.

The hind border of the parieto-mastoid platform is undulate; gently convex at the middle, where it is formed by the parietal (ib., 7), concave on each side, where it is carried out by the mastoids (ib., 8).

In *Crocodilus niger* this border is straight; in *Croc. palustris* it is undulate, but the middle parietal convexity is much less than the lateral, concave, mastoidean curves, owing to the relatively narrower extent of the parietal bone. The lateral borders of the supra-cranial platform, due to the mastoids (ib., 8) and post-frontals (ib., 12), present, in *Nannosuchus*, a gentle sigmoid curve. In most modern *Crocodilia* these borders are straight, running parallel in *Croc. niger*, slightly convergent forwards in *Croc. cataphractus* and *Croc. intermedius*.

The breadth of the platform is to that of the skull, taken across and including the

[1] 'Catalogue of Osteology, Mus. Coll. Chir.,' 4to, 1853, p. 153, No. 691.

[2] Supplement (No. viii) in Palæontographical Soc. Volume for 1878, Plate VI.

zygomatic arches, as 8 to 10 in *Nannosuchus;* in *Croc. niger* the platform is little more than half the breadth of the skull taken across the hind part of the parieto-mastoid or upper temporal apertures; in *Croc. palustris* the platform occupies half the breadth of the skull taken at the same part.

The upper temporal apertures (T) have the same relative size as in *Petrosuchus,* but they differ in shape, being less circular, the longer diameter being longitudinal, or in the skull's axis. As far as the orbits are preserved these do not exceed in size the upper temporal apertures. This character of the Mesozoic Crocodile is retained in the present dwarf species. A super-orbital bone strengthened the upper eyelid; it retains its connections with the frontal (11), post-frontal (12), and pre-frontal (14) in the left orbit (*o*); but has become slightly detached in the right orbit (*o'*). The nasal bones (15) terminate in a point distant from the external nostril by rather more than the diameter of that aperture, which accordingly is single and exclusively bounded by the premaxillaries. In this character *Crocodilius cataphractus* and *Croc. intermedius* resemble *Nannosuchus;* but the upper jaw is longer and more slender in proportion in both these existing Crocodiles than in the Purbeck species; in both, also, the upper temporal apertures are relatively smaller than in *Nannosuchus.*

In the character of the nasal bones and conformation of the external nostril *Nannosuchus* resembles *Goniopholis,*[1] but the supra-temporal apertures are more oblong and the maxillaries are not so out-swollen as they approach the premaxillaries. The facial part of the skull, from the front border of the orbit forwards, equals the extent of the skull from the same part to the occiput in *Nannosuchus;* in *Goniopholis* the facial part of the skull, so defined, is one third longer than the extent behind. The mutilated state of the unique skull of *Petrosuchus*[2] prevents a similar comparison being made.

The sculpturing of the upper surfaces of the exposed parts of the skull in *Nannosuchus* presents the common Crocodilian character of minute subcircular pits, leaving a reticulate disposition of the intervening bone.

Genus—THERIOSUCHUS,[3] *Owen.*

Species—*Theriosuchus pusillus.* Plate III, figs. 3—16; Plate IV.

This Crocodile, somewhat smaller in size than the preceding species, approaches nearer to the type of the broad-faced Alligators in the proportion of the antorbital part of the skull.

The dentition is more modified than in any other known Crocodile, recent or extinct, and approaches that which characterises the Theriodont order of Triassic Reptilia.

[1] Supplement, &c., No. viii, Plate V, fig. 1, *t.*

[2] Gr. θηριον, wild beast; σοῦχυς, crocodile.

[3] Supplément, &c., No. viii, Plate VI, fig. 1.

The premaxillary teeth are five in number in each bone; the three middle ones subequal, the first and fifth smaller. The maxillary teeth are divisible into laniaries and carnassials or trenchant molars. The first maxillary tooth is small (Pl. III, fig. 5); the second and third gain quickly in size, the latter (*a*) assuming the character of a canine; the fourth tooth (*b*) is a still larger canine; the fifth (*c*) and sixth (*d*) decrease in size somewhat suddenly, but in length rather than breadth of crown, and terminate the series projecting from the convex part of the alveolar border of the maxillary. The tooth *c* or *d* may be said to terminate the laniary series. Beyond *d* the teeth lose length and slightly gain in breadth; the crown assumes a triangular, laterally compressed, or lamellate form, and the enamel is transversed on the outside by fine but distinct lines (ib., fig. 6, *e*). Of these sectorial or carnassial molars some of the detached specimens of maxillary (figs. 7 and 11) indicate as many as eight or nine. The broad base or root of each tooth is not inserted into a separate and complete socket, but is lodged in a recess of the outer alveolar wall; moreover, the partitions between these recesses are low or partial, and the teeth appear to have been applied thereto, without being so completely confluent therewith, as in the pleurodont mode of fixation of the teeth in certain Lizards. Hence, in some of the specimens of the maxillary bone the incisors and canines only are retained, being rooted each in its own complete socket; while the molars have fallen out, and their partially separated recesses are shown, as in figures 7 and 11.

In the lower jaw the foremost tooth is rather larger than those which interlock with the middle premaxillary or 'incisor' teeth above; but not any of the succeeding laniary teeth attain the size of the upper canines. The twelfth tooth, counting backwards, assumes the lamellate, triangular shape of striate crown characteristic of the superior sectorials; and the inferior ones were lodged, like those above, in a common depression of an outer alveolar wall, developing the ridges dividing such depression into the dental recesses, as shown in fig. 16, Pl. III. This approximation to a Lacertian dental character might seem ground for something more than a family section of the order *Crocodilia;* but the quasi-pleurodont attachment of the hinder teeth in *Theriosuchus* is only an extension of the character affecting some of the teeth in existing species of Crocodile.[1]

In the cranial platform of *Theriosuchus* the medial parietal part of the hind border is less convex and the two outer parts are more concave by reason of the further backward production of the mastoids than in *Nannosuchus*. The lateral borders of the sculptured part of the platform are more convex than in that genus. This is owing to the greater proportion of the outer and posterior angles of the platform which is abruptly depressed

[1] It is noted in the *Alligator niger*. "No. 765. The right ramus of the lower jaw, from which the posterior part of the inner alveolar wall has been removed, showing the five posterior teeth lodged in a common alveolar groove." 'Osteological Catalogue, Museum of the Royal College of Surgeons,' 4to, vol. i, p. 167 (1853).

below the level of the sculptured surface of the mastoid, and which becomes smooth like the contiguous and lower-placed tympanic. This character, shown in the subject of fig. 3, Pl. III, usefully indicated fragmentary parts of the skull of other individuals of the species, such as are figured in fig. 1, 12′, Pl. IV. The supra-temporal vacuities are relatively larger than in *Nannosuchus*. The intervening tract of the parietal, rather more canaliculate than in *Nannosuchus*, is divided by a mid ridge in two of the cranial specimens, and partially so in the more complete skull.

No palpebral ossicle is preserved in the orbit (*o*). The pointed ends of the nasals are produced so as to divide the outer nostril into two, as in some specimens of *Crocodilus niger*; were this a character of generic value, it might unite *Theriosuchus* with *Halcrosia*, Gray.[1]

The alveolar part of the maxillary in which the canines are developed make a corresponding convex extension of its outer border, as in *Goniopholis*.

The extent of the 'symphysis mandibulæ' and the angle of divarication of the rami are shown in fig. 4, Pl. III.

The matrix was removed as far as practicable from the palatal surface of the skull (fig. 4) and exposed a portion of the basisphenoid (5), of the pterygoids (24), of the palatines (20), and palatal plates of the maxillary (21); the pterygo-maxillary vacuities (*y*) and the hind portion of the palatonares (*n*) were brought into view. What seems to be a portion of the hind part of a mandibular ramus was so wedged down upon a part of the palatal surface that, in regard to the fragile character of this unique skull, it was deemed unadvisable to attempt its removal.

In Pl. IV a portion of the skeleton of *Theriosuchus pusillus* is figured. It is of one individual. In the slab of matrix in which it is imbedded the fore part, marked A, A, is continued on from the hind part with an interval of the extent marked B. At this interval the slab has been broken across, but the parts appear to have been naturally readjusted before the specimen was fixed in its present frame. The position in which the two portions of the skeleton are figured relates to the convenience of size of the Plate.

The skull has been displaced and fractured, but the contiguity of the preserved portion with the vertebral column supports the conclusion that it formed part of the skeleton of the same individual. It thus serves to determine the species to which the subject of Plate IV belonged.

The part of the skull includes the parieto-mastoid platform (7, 12′) with the tympanic (28) and the squamosal (27). The articular surface of the tympanic for the mandible shows the Crocodilian character. The median or sagittal ridge of the parietal is well marked, and is continued along the mid-frontal. This character is partially effaced by mutilation in the more entire skull (Pl. III, fig. 3). It is well shown in the frontal bone indicating the largest of the specimens of *Theriosuchus* (Pl. III, fig. 8).

[1] 'Trans. Zool. Soc.,' vol. vi, p. 135.

The vertebral centrums of the trunk show the shallow Amphicœlian character of those of the *Goniopholis* and Teleosaurians. The smooth under or dermal surface of part of the two median rows of the dorsal scutes are shown in the fore half of the skeleton. In the hind half the upper or epidermal surface of the scutes is exposed, showing in most the submedial longitudinal ridge. This is wanting in certain, probably lateral, scutes, of which a group is exposed at the fore part of the anterior portion of the skeleton. One of these unridged, but toothed, scutes is figured at fig. 3, Pl. IV.

Of the limb-bones preserved may be recognised the right scapula (51) and humerus (53), the left humerus (53) with the radius (54) and ulna (55), followed by some dislocated metacarpals and phalanges of the fore-foot.

In the hind portion of the skeleton (fig. 2) the right femur (65), tibia (66), fibula (67), with the four metatarsals and scattered phalanges, are preserved.

All the limb-bones show the ordinal Crocodilian characters, but the proportion of the fore to the hind limb is that of the Procœlian division, not that of the Teleosaurs.[1] In this respect, as in the proportions of the maxillary bones and teeth, the advance to Tertiary types of Crocodilia is manifested. As in these the *Theriosuchus* was better adapted for locomotion on dry land than were the Teleosaurs.

In *Theriosuchus* the breadth and shortness of the antorbital part of the skull in proportion to the part behind exceeds that in any modern broad-snouted Crocodile. Even in the young 'Crocodile à deux arrêtes,' figured in Pl. I of Cuvier's 'Ossemens Fossiles,'[2] a transverse line across the fore part of the orbits equally bisects the skull, omitting the mandible. In *Theriosuchus* the same line leaves in advance six thirteenth parts of the length of the skull.

This proportion suggested at first view the immature state of the individual to which the subject of fig. 3, Pl. III, had belonged; but of the numerous evidences of *Theriosuchus pusillus* none were larger than those figured in Pl. IV, and in figs. 3, 4, 8, 14, 16, of Pl. III: several other fragmentary evidences had come from smaller individuals.

I conclude, therefore, that, as in the case of most species notable for their diminutive size, immature characters of the larger species of the genus are associated with such dwarfishness of the adults. The only known mammals of the Purbeck period characteristic, moreover, like the dwarf Crocodiles, of the fresh-water 'Feather-bed' deposits, are of diminutive size, and the carnivorous Saurians seem to have been thus adapted in dimensions and force to their prey.

I estimate the average length of a mature *Theriosuchus* at 18 inches. The length of the skull, taken as that of the mandible, is 3 inches 6 lines. In the articulated skeleton of a modern Crocodile the angle of the lower jaw extends to the third cervical vertebra.

[1] Compare Tab. XI, 'Monograph on the Fossil Reptilia of the London Clay,' part ii, *Crocodilia* and *Ophidia*, Palæontographical volume, 4to, 1850.

[2] Quarto, tom. v, 2de partie.

In *Alligator lucius* the trunk from the third cervical to the last sacral vertebra inclusive is nearly equal to two lengths of the skull; the length of the tail is $2\frac{1}{3}$ lengths of the skull. The trunk of *Theriosuchus* so defined includes two lengths of the skull. The tail, as indicated by fig. 2, Pl. IV, equalled $2\frac{1}{3}$ lengths of the skull.

In the long-jawed Gavials and Teleosaurs the trunk includes about $1\frac{1}{4}$ length of the skull; but the tail is proportionally longer than in the short- and thick-jawed Crocodiles.

Crocodilian vertebræ. Plate I, figs. 4—12.

Of the numerous scattered vertebræ in the different slabs of the Purbeck matrix those specimens have been selected for figuring which exemplify the Crocodilian characters of different portions of the vertebral column.

The subject of fig. 4, Pl. I, is from the neck or fore part of the trunk, in which the hypapophysis (*hy*) has not subsided on the under surface of the centrum; the processes for the head ('parapophysis,' *p*) and tubercle ('diapophysis,' *d*) of the proximally bifurcate rib are well developed. The pre- (*z*) and post- (*z'*) zygapophyses, together with the neural spine (*n.s.*), complete the series of developments of this complex type of Crocodilian vertebræ.[1]

Figs. 5 and 6 are two consecutive, but slightly dislocated, vertebræ from the hinder part of the trunk. The long and broad diapophyses show the notch (*d*) where the simple and short hinder ribs were articulated, each by a single joint, with the rest of their osseous 'segment' or vertebra.[2]

Figs. 7 and 8 are side views of mutilated hinder trunk vertebræ.

Fig. 9 gives a back view of one of the sacral vertebræ, showing the robust processes represented by coalesced pleurapophyses. The suture is traceable by which the latter articulate with both centrum and neural arch.[3]

Fig. 10 is a caudal vertebra, with the hæmal arch and spine (*h*); a front view of the latter is given in fig. 11; the vertebra is from that part of the tail where the pleurapophyses cease to be developed.[4]

Fig. 12 shows the completely ossified substance in a section of a dorsal centrum.

Fig. 13 probably belonged to *Brachydectes minor*.

All these and other detached vertebræ indicate the dwarfed proportions of the *Crocodilia* characteristic of the fresh-water deposits of the 'Feather-bed.' Many

[1] No. 687, Osteological Catalogue, 1853.

[2] No. 689, op. cit., p. 153.

[3] It accords with the character of the sixth cervical vertebra in *Gavialis gangeticus* ('Catal. of Osteology, Mus. Coll. Chir.,' 4to, vol. i, p. 152, No. 684), save in the minor development of the hypapophysis, which indicates a position in the vertebral column somewhat further back.

[4] See No. 686 of the same series and 'Catalogue,' loc. cit.

correspond in size and shape with those shown *in sitú* in *Theriosuchus*, Pl. IV. The subjects of figures 4—10 I am disposed to refer to *Nannosuchus*.

Crocodilian Scutes. Pl. II, fig. 4, 5, 11, 12.

In almost every slab containing Crocodilian remains are scutes, or portions or impressions of scutes. They include the 'peg-and-groove' type, the hexagonal with sutural margins, and the ordinary quadrate with bevelled edges, either plain or single-ridged. All show the Crocodilian pitted or reticular sculpturing on one side, the smooth surface on the opposite.

The scutes exemplified in Plate II, figs. 4 and 5, partly by portions, partly by impressions, may be referred both by contiguity and proportional size to the larger examples of *Nannosuchus gracilidens*. Some scutes of this type, of rather larger size, and with the smooth, overlapped, anterior border relatively broader and more elevated than in *Goniopholis crassidens*,[1] may belong to the smaller species of *Goniopholis* (*G. tenuidens*) or to the larger kind of *Brachydectes*. A smaller-sized peg-and-groove scute would fit *Brachydectes minor;* the smallest and most numerous of all are commonly associated with evidences of *Theriosuchus pusillus*.

The most instructive scutal fossils are those which exemplify the relative position and mode of interlocking of the articular mechanism. Of these are figured two groups, one showing the outer (ib., fig. 11), the other the inner (ib., fig. 12) surfaces.

These specimens afford grounds for additions to the original description of the peg-and-groove modification of Crocodilian armature.

To the "process continued from *one of the angles* vertically to the long axis of the scute"[2] may be added "from the anterior and external angle;" and for "the depression on the opposite angle of the adjoining scute" may be written "on the under surface of the posterior and external angle of the scute in advance."

When the medial dorsal series of scutes are seen in natural connection from the outer surface the articulating peg is concealed, as in the two hinder pairs of the three shown in fig. 11, Pl. II. When the inner surface of a similar series is exposed, as in fig. 12, the mode of application of the pegs and grooves comes into view.

The scutes of the two medial rows along the back of these Purbeck Crocodiles join each other at the medial line by a close contact of the inner borders—a kind of 'harmonia' or toothless suture. Ventral scutes usually show thicker, more sutural, margins. The dorsal scutes upon the tail lose the peg and groove, are longest in longitudinal diameter, and mostly support a longitudinal submedial ridge on the outer surface; at least in *Theriosuchus pusillus* (Pl. IV, fig. 2).

[1] 'Supplement,' No. viii; Pal. Vol., 1878, p. 2, Pl. IV, fig. 1.

[2] 'Report on British Fossil Reptiles,' 1841, p. 70.

Genus—NUTHETES, *Owen*.[1]

Species—*Nuthetes destructor*.

In a former 'Monograph on the Fossil Lacertian Reptiles of the Purbeck Limestones' the above genus and species were founded on portions of jaw and teeth, kindly transmitted to me by Charles Wilcox, Esq., of Swanage, Dorsetshire.

In Mr. Beckles' collection further evidence of *Nuthetes destructor* is afforded by the portions of jaw (Pl. II, figs. 13 and 14) and by numerous detached teeth, ranging in size from a length of enamelled crown of 5 mm. to 20 mm. (fig. 15, *c*), and with variations in the proportion of length to basal breadth (comp. fig. 15, *d*, *e*, with *a*, *b*).

The teeth in the mandibular fragment accord in size and shape with those of the original or type specimen;[2] they are laterally compressed, strongly recurved, and combine a basal fore-and-aft breadth of 3 mm. with the length of 5 mm. (straight). They likewise show the "excavation or longitudinal depression on the side of the base."[3] The coronal enamel does not extend over this depression, but is continued along its margins, and to a greater extent on that next the convex border of the crown than on the opposite side. In the portion of jaw, originally figured, with seven more or less perfect tooth-crowns, two of these indicate a longer and more slender shape than the rest. Several detached teeth of this type have been exposed in portions of the 'Feather-bed Marl' in the Becklesian series. Some of these, exemplifying difference of size, are figured in Plate II, fig. 15.

In all these tooth-crowns the characteristic fore and hind finely denticulate ridges are discernible, as shown in the magnified view (fig. 16); the rest of the enamel is smooth and even, as in the type of *Nuthetes destructor*. Of this species I am disposed to regard the specimens above described as indicative of the range of size according to growth of individuals rather than as exemplifying specific modifications of the genus.

DERMAL BONES ('GRANICONES').

In many portions of the matrix of the 'Feather-bed' are ossicles of a conical shape, the cone showing various degrees of elevation, with a granulate surface, the base being flat and smooth, or faintly and minutely pitted. These 'granicones' I regard as dermal bones,

[1] 'Monograph on the Fossil Lacertian Reptiles of the Purbeck Limestones,' Palæontological Society's volume, issued for 1858, p. 31. 1861.

[2] 'Quarterly Journal of the Geological Society,' 1854, p. 120.

[3] Ib., ib.

In fig. 18, Pl. II, is represented a 'granicone' with a basal breadth of 8 mm., and a length or height of cone of 14 mm. In Fig. 19 the base is oblique, reducing the shortest side of the cone to a height of 8 mm. In this, as in some of the similarly shaped 'granicones,' part of the basal margin is raised or prominent, sometimes formed by a single series of close-set granules, as in Fig. 20. Those on the surface of the cone are less regularly disposed, but at some parts affect a longitudinal arrangement (Fig. 21.) The apex shows various degrees of obtuseness, which finally reduces the granulate or exterior surface of the cone to a moderate convexity, but the conical shape is the rule. The smallest of such 'grani-cones' has a basal breadth of 3 mm., a length of 5 mm.

Slices of these enigmatical fossils prepared for the microscope demonstrated the absence of the structures characteristic of piscine dermal bony cones and spines. Moreover, the geological deposit (a subdivision of the Purbeck series) containing the granicones is a fresh-water one, and their structure was equally distinct from the ganoid dermal defences of the *Sturionidæ* or other fishes habitually frequenting lakes or rivers. The dermal scutes of *Theriosuchus* are notable for the greater number of the canaliculi, and the more regular 'lay,' or disposition, of the 'lacunæ' or bone cells, than in Lacertians; also by the wider 'sinuses' or unossified tracts. In the dimensions, size, shape, and number of the 'canaliculi;' in the minor regularity of the 'lay' of the lacunæ, and in the less proportion in both number and dimensions of the sinuses, the bony tissue of the granicones resembled that in Lacertians; and in this conclusion from microscopical characters,[1] combined with the evidence of the association, and the contiguity of the granicones, with the unquestionable fossil remains of *Nuthetes destructor*, I derive the grounds for referring them to that extinct genus and species.

Among modern Lizards the singular '*Moloch horridus*' of Australia exemplifies dermal scutes most nearly resembling these 'granicones' in shape; but the horny exterior is supported by dense fibrous tissue, not bone. It may be that we have in them a formal exemplification of the dermal armour of *Nuthetes destructor*. If so, the association of a Lizard of such forbidding physiognomy with small Marsupials having their nearest of kin in Australia would be worthy of note.

At the conclusion of my former Monograph on Mesozoic (Wealden and Purbeck) *Crocodilia*, allusion was made to the differences they presented in characters of the bony palate, extent of attachment of mandibular muscles, vertebral articulations, and dermal armature, from the Neozoic *Crocodilia*; differences which suggested the relation of such modifications in the Tertiary and existing Crocodiles and Alligators to freer or more frequent life on dry land, and greater power of grappling with and drowning large terrestrial mammals.

One of these reptiles having seized and submerged a tiger or buffalo, admits the water into its wide, unlabiate mouth, by the spaces to which the thickness of the part of the prey gripped keeps asunder the upper and the lower jaws. Thus, the part of the mouth

[1] See 'Journal of the Royal Microscopical Society,' vol. i, No. 5, p. 233, pls. xii and xiii.

not occupied by the prey is filled with the fluid in which the mammal is being dragged and drowned. "The closure of the exterior nostrils"[1] would not prevent the water entering the 'glottis.' A special arrangement is requisite for this purpose, and such arrangement, as it exists in Neozoic Crocodiles, is incompatible with the relative position of "the posterior nares" and the glottis in the Mesozoic Crocodiles. The question is, with a closure of the external nostrils and the exclusion of water admitted by the mouth into the nasal passage, how is the water to be prevented from getting into the windpipe? We know how this is effected in the Cetaceans; and modern Crocodiles have as efficient a mechanism to the same end though on a different plan, but requiring a size and position of the palatonares which constitutes one of the best marked cranial characters differentiating the Mesozoic and Neozoic *Crocodilia*.

In all the Crocodiles contemporary with "large and active mammals"[2] there is a double valvular structure at the back of the mouth, which prevents the water having access to the mouth, from entering either the hinder nostril or the glottis. A membranous and fleshy fold hangs, like a curtain, from the hind border of the roof of the mouth, and answers to our 'velum palati:' the other valve is peculiarly crocodilian; it is a broad, gristly plate, which rises from the root of the tongue, carrying with it a covering of the lingual integument; and, when the palatal valve is applied to it, they form together a complete partition wall, closing the back of the mouth, between which and "the posterior nares" it is situated, shutting off both the latter aperture and the glottis from the mouth.

To make this mechanism available, the hind nostril is reduced in size, and such reduction is shown in the skull. The palatonaris is also placed far back, and its plane instead of being horizontal is tilted up at the angle which makes the operation of the two parts or folding doors of the partition most effective in closing the oral chamber posteriorly.[3] If the submergence of the Crocodile, with its "large mammalian"[4] prey, should last so long as to render it needful for the reptile to take a fresh breath, it can protrude its prominent snout from the surface of the river, and inhale a current of air which will traverse the long meatus and enter the glottis by the chamber common to nose and windpipe, which is shut off from the mouth by the above-described structures. We have no ground for inferring such from the bony palate in amphicœlian Crocodiles; the difference in its size and position are such as to have deceived both Bronn and De Blainville as to the position and homology of the palatonares in *Teleosaurus*.[5]

The subjects of the present Monograph bear unexpectedly, and in an interesting degree, on another objection, raised during the discussion at the Geological Society of

[1] 'Quart. Journ. of Geol. Soc.,' May, 1878, p. 429.

[2] Loc. cit., p. 425.

[3] 'Proceedings of the Zool. Soc.,' October 25th, 1831, p. 139.

[4] Ib. ib., p. 426.

[5] 'Abhandlungen über die Gavial-artigen Reptilien der Lias-formation,' fol., 1841, pp. 12, 16, 24.

London, on the topics touched upon at the conclusion of the preceding Monograph, and subsequently submitted in greater detail to that body. The objection was, that "warm-blooded animals did actually exist contemporaneously with the Mesosuchian Crocodiles."[1] As the only examples of the Mammalian class of which I was cognisant were the subjects of the undercited Monograph,[2] and a few other species of like diminutive size, it did not seem to me to affect a question exclusively bearing upon "large Mammalian quadrupeds."[3] It seems, however, that the Crocodiles which most abounded, if we may judge from the proportion of their fossil remains in the fresh-water deposits of the 'feather-bed' subdivision of the Purbeck series, were related in size to their contemporary diminutive Mammals. The Spalacotheres, Peralestes, Stylodons, Triconodons, &c., may well have been the prey of the dwarf Crocodiles of the locality. For these were reduced to dimensions which forbade them to disdain such succulent morsels, and at the same time they were suitably armed and limbed for the capture of the little Marsupials.

[1] Hulke, 'Quarterly Journal of the Geological Society,' May, 1878, p. 428.

[2] "On the Fossil Mammalia of the Mesozoic Formations," Palæontographical Soc. Volume for 1870.

[3] 'Quart. Journal,' *ut supra*, pp. 425, 426.

PLATE I.

Genus—Goniopholis.

Fig.

1. Dentary portions of the mandible of *Goniopholis tenuidens*: 1 *a*, outer side of anterior canine; 1 *b*, inner side of anterior canine: *b'*, the same magnified.

Genus—Brachydectes.

2. Side view of left mandibular ramus of *Brachydectes major*.
3. Side view of left mandibular ramus of *Brachydectes minor*.

Order—Crocodilia.

4. Front view of an anterior trunk-vertebra.
5. Upper (neural) view of a posterior trunk-vertebra.
6. Upper (neural) view of a following vertebra.
7. Side view of a trunk-vertebra.
8. Side view of a trunk-vertebra.
9. Back view of a sacral vertebra.
10. Side view of a caudal vertebra.
11. Front view of hæmal arch and spine of do.
12. Longitudinal vertical section of the centrum of a trunk-vertebra.
13. Side view of three dorsal vertebræ of *Brachydectes minor*?

The figures are of the natural size save where otherwise expressed.
From the Middle Purbeck; in the British Museum.

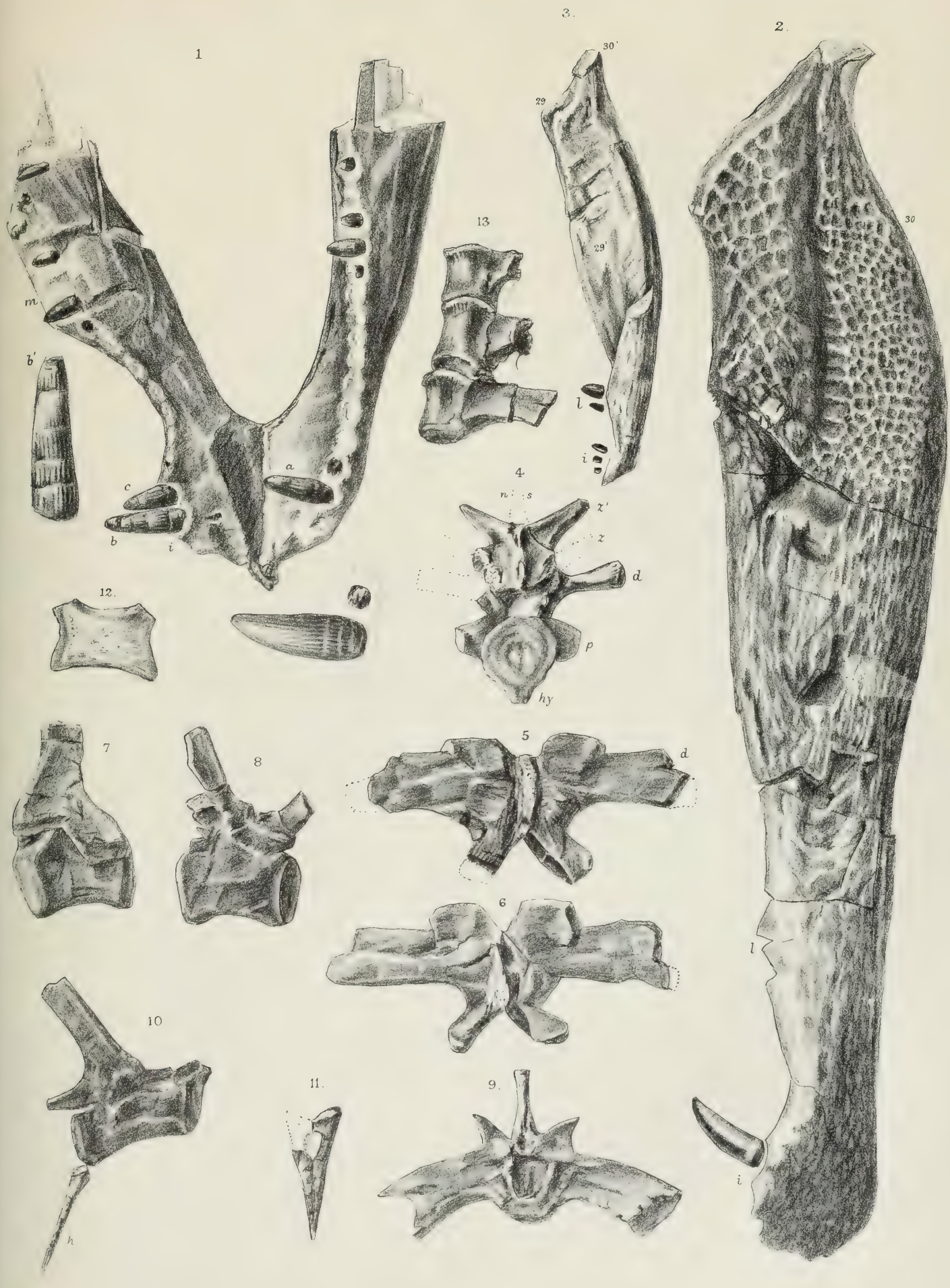
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PLATE II.

Genus—NANNOSUCHUS.

FIG.

1. Dentary portions of mandible of *Nannosuchus gracilidens.*
2. Outer side of right anterior canine of do., magn.
3. Oblique view of a trunk-vertebra of do.
4. Portion and impression of a dorsal scute of do.
5. Portion of a larger dorsal scute of do. (the subjects of figs. 3, 4, and 5, are on the same slab as fig. 1).
6. Under view of dentary portions of mandible of *Nannosuchus gracilidens.*
7. Detached anterior canine of probably the same mandible.
8. Outer side view of right ramus of mandible of *Nannosuchus gracilidens* (the ends are drawn too far apart).
9. Portions of dentary elements of mandible of do.
10. Humerus of do.

Incertæ species.

11. Outer view of three pairs of dorsal scutes.
12. Inner view of four pairs of dorsal scutes.

Genus—NUTHETES.

13 and 14. Portions of mandible and teeth of *Nuthetes destructor.*
15. Five detached teeth of do.
16. Side view of crown of a tooth of do., magn.
17—21. Dermal bones or 'granicones,' probably of *Nuthetes.*
22. Section of a granicone, magnified 12 diameters.
23. Ib. ib. magnified 500 diameters.

Genus—THERIOSUCHUS.

24. Anterior caudal vertebra, with articular end in outline.

The figures are of the natural size save where otherwise expressed.
From the Middle Purbeck; in the British Museum.

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PLATE III.

Genus—NANNOSUCHUS.

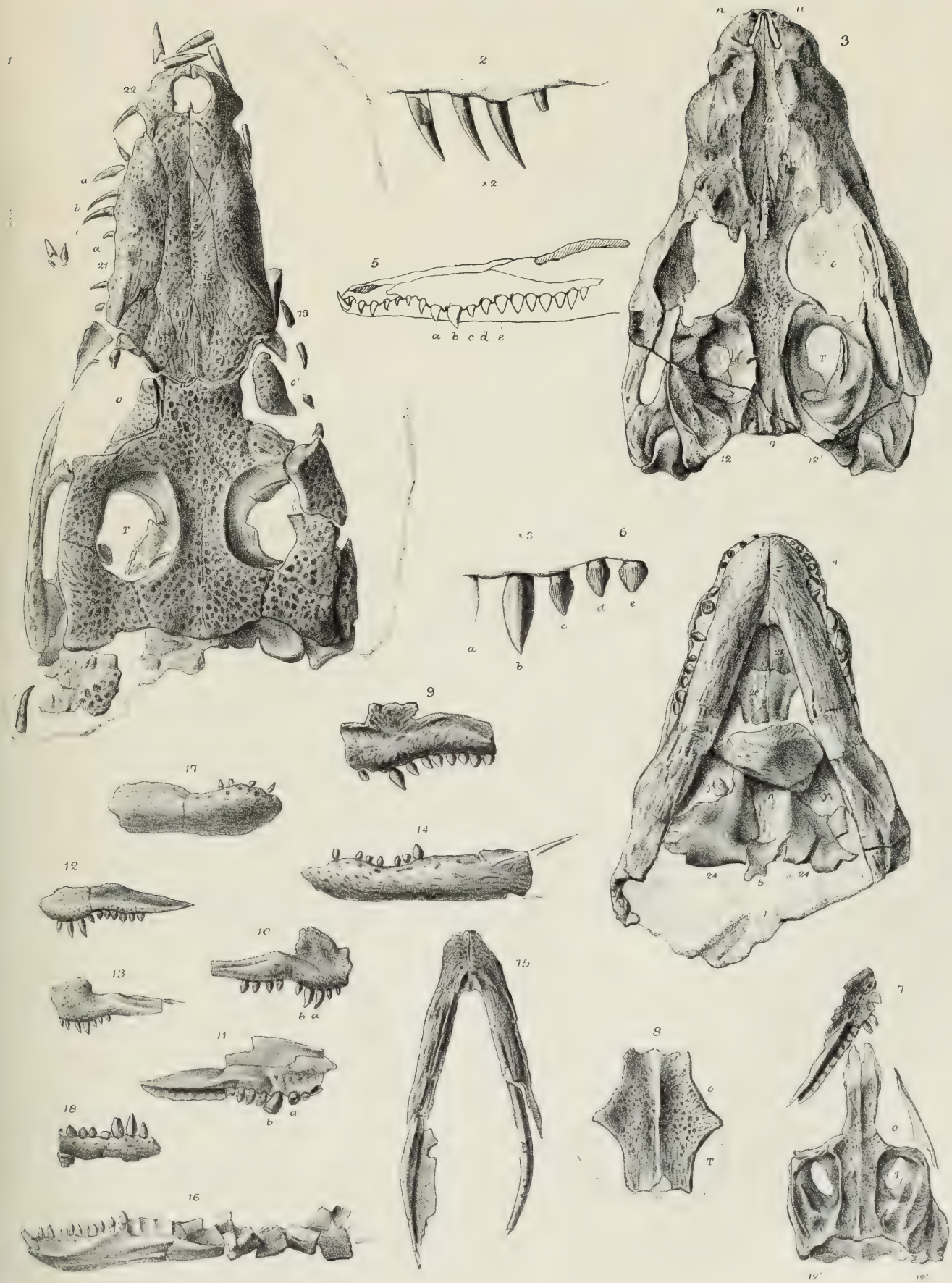
FIG.

1. Upper view of skull of *Nannosuchus gracilidens*.
2. Crowns of four teeth, *a*, *b*, *c*, *d*, in fig. 1, magnified 2 diameters.

Genus—THERIOSUCHUS.

3. Upper view of skull of *Theriosuchus pusillus*.
4. Under view of the same skull.
5. Side view of facial part of the same skull.
6. Crowns of five teeth, *a*, *b*, *c*, *d*, *e*, in fig. 5, magnified 3 diameters.
7. Upper view of cranium and inner view of left maxillary, *Theriosuchus pusillus*.
8. Frontal bone, *Theriosuchus pusillus*.
9. Part of left maxillary, ib.
10. Part of right maxillary, ib.
11. Left maxillary, inner side view, ib.
12. Right maxillary, young individual, ib.
13. Right maxillary, young individual, ib.
14. Left dentary, side view, mature individual.
15. Dentary and angular parts of mandible, under view, ib.
16. Dentary and fragments of mandible, inner side view, ib.
17. Fore part of right dentary, side view, ib.

The figures are of the natural size save where otherwise expressed.
From the Middle Purbeck; in the British Museum.



C.L. Griesbach lith.

W.West & Co. imp.

1, 2, Nannosuchus; 3-16, Theriosuchus.

PLATE IV.

Theriosuchus pusillus.

Fig.

1. Portion of skull, trunk-vertebræ, and bones of fore limbs.
2. Bones of right hind limb and ridged caudal scutes of the same skeleton.
3. An unridged scute with peg, *a*.
4. Under surface of a scute, showing peg and groove, *b*.

All the figures are of the natural size.
From the Middle Purbeck ; in the British Museum.

C.L. Griesbach lith

W.West & Co imp.

Theriosuchus

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MONOGRAPH

ON THE

BRITISH FOSSIL

ELEPHANTS.

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PART II.

DENTITION AND OSTEOLOGY OF ELEPHAS PRIMIGENIUS (*Blumenbach*).

PAGES 69—146; PLATES VI—XV.

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MONOGRAPH

ON THE

BRITISH FOSSIL ELEPHANTS.

ELEPHAS PRIMIGENIUS.

I.—INTRODUCTORY.

The vast quantities of remains of the Mammoth, *Elephas primigenius* (Blumenbach), discovered of late years in and around the British Islands represent almost every element of the skeleton, and therefore afford sufficient materials for the descriptive osteology of the species. On that account I propose in the following Monograph to describe, first, the Axial, and, secondly, the Appendicular Skeleton.

The early history of the discovery of Elephantine remains in the British Islands and elsewhere is fully recorded in the works of Cuvier, De Blainville, Bronn, Owen, and Falconer. The confusion and uncertainty, however, arising from the belief in the unity of the species which, with the exception of Falconer, was maintained more or less by these and other comparative anatomists, make many of the records so far valueless, inasmuch as wherever the data do not clearly indicate the characters of specimens it must remain doubtful whether they refer to *Elephas primigenius E. antiquus*, or *Elephas meridionalis*.

II.—DISTRIBUTION.

Remains of *Elephas primigenius* have turned up in many localities in England, and have been found so frequently associated with *E. antiquus*, that in the absence of proper confirmation I will only enumerate the instances known either to myself or to geologists and palæontologists experienced in manipulating molars of fossil Elephants.

I have availed myself largely of Professor Boyd Dawkins' List,[1] and he has kindly revised my notes on the Distribution, and has added some localities previously unknown to me.

The foreign distribution might doubtless be very greatly extended if all the localities of specimens in European Museums were recorded. Indeed, the following is by no means advanced as a complete list, but I believe it will be found accurate as far as it extends. I have made distinctions between (1) remains from River, Valley, and Alluvial Deposits, (2) remains from Caverns, and (3) Dredged specimens.

1. *Remains from River, Valley, and Alluvial Deposits.*

Neither Cornwall nor Devon, as far as known to me, have produced any remains of the Mammoth from their river, gravel, and surface deposits.

In Somersetshire, remains have been met with at Hinton (Mus. Roy. Coll. Surg. of England), Larkhall and Hartlip (Mus. Geol. Surv.),[2] Loxbrook, St. Audries, Weston-super-Mare, Chedzoy, Freshford (Dawkins).

In Gloucester, at Gloucester (Dawkins), Barnwood (Dawkins), Beckford (Dawkins), Stroud (Dawkins), Tewkesbury (Owen).

In Dorsetshire, at Bridport (Mus. Geol. Surv.), Portland Fissure (Busk, Mus. Geol. Soc. London).

In Hants, in Gale Bay[3] (B. M.), Newton (Woodwardian Mus. and Mus. Geol. Surv.).

In Wilts, at Christian Malford (Oxon. Mus.), Fisherton (Blackmore and Sanford), Milford Hill, near Salisbury (Blackmore).

In Berks, at Maidenhead and Taplow (Wood. Mus.), Reading, Hurley Bottom (Oxon. Mus.).

In Oxfordshire, at Yarnton, "in gravel," Bed of Cherwell, City of Oxford, "in gravel," Wytham and Culham, "in gravel" (Oxon. Mus.).

In Essex, at Lexden (B. M., Wood. Mus., Mus. Geol. Surv.), Orford, Heddingham, Lamarsh, "railway cutting," Isle of Dogs (B. M.), Walton-on-the-Naze (Wood. Mus.), Ilford (B. M., and Mus. Geol. Surv.), Wenden (Mus. Geol. Surv.), Harwich (B. M.), Colchester (Dawkins), Ballingdon (B. M.), Walthamstow (B. M.).

In Herts, at Camp's Hill (Dawkins).

In Sussex, at Bracklesham Bay, "raised beach" (B. M.), Brighton, "gravel

[1] "British Post-Glacial Mammals," 'Quart. Journ. Geol. Soc.,' vol. xxv, p. 196.

[2] The Museum of the Geological Survey being incorporated with that of Practical Geology the two terms when used here must be considered synonymous.

[3] I cannot find out whether this specimen was dredged or found on dry land.

and raised beach" (B. M. and Mus. Geol. Surv.), Lewes, Valley of Arun, Pagham (Dawkins).

In Suffolk, at Ipswich "railway cutting" (B. M.), Hoxne (Dawkins).

In Norfolk, at Bacton, Cromer (B. M.), Yarmouth (Owen).

In Cambridge, at Barrington, "gravel," Barnwell, Chesterton, Great Shelford, Barton, Westwick, Hall (Wood. Mus.).

In Huntingdonshire, at Huntingdon, "railway cutting" (B. M.), St. Neot's, (Wood. Mus.).

In Bedfordshire, at Leighton Buzzard (Oxon. Mus.).

In Middlesex, at London, under various streets, &c., to wit, St. James's Square, Pall Mall, Kensington, Battersea, Hammersmith, &c., "in river gravel" (B. M. and Mus. Geol. Surv.), Turnham Green (Busk), Bed of Thames at Millbank, Brentford, Kew, Acton, Clapton, &c. (B. M.), Thames, near London (Owen), Kingsland (Owen).

In Surrey, at Wallington, Tooting (B. M.), Peckham (B. M.), Dorking, Peasemarsh, near Guildford (Prestwich).

In Kent, at Crayford, Erith (B. M. and Mus. Geol. Surv.), Dartford, Aylesford, Hartlip, Otterham (Mus. Geol. Surv. and B. M.), Isle of Sheppey, Broughton Fissure, Medway (B. M.), Sittingbourne (Mus. Geol. Surv.), Newington, Green Street Green, Bromley (Dawkins), Whitstable (Dawkins).

In Bucks, at Fenny Stratford (B.M.).

In Northamptonshire, at Oundle, Kettering, Northampton (B. M.).

In Warwickshire, at Rugby, Wellesborne, Lawford (B. M.), Bromwich Hill, Halston (Dawkins), Newnan (Buckland).

In Worcestershire, in Stour Valley (B. M.), Droitwich, Banks of Avon, Fladbury, Malvern (Dawkins).

In Leicestershire, at Kirby Park "gravel" (Wood. Mus.).

In Staffordshire, at Copen Hall (Dawkins), Trentham (Buckland).

In Cheshire, at Northwich ("pre-glacial," Dawkins).

In Lincolnshire, at Spalding (B. M.).

In Yorkshire, at Whitby, Aldborough, Gristhorpe Bay[1] (Wood. Mus.), Harswell, Leeds (Dawkins), Bielbecks (Phillips), Brandsburton (Dawkins), Middleton, Overton, Alwick, Hornsea (Owen).

In Herefordshire, at Kingsland (Falconer).

The remains of Mammoth from glacial and other deposits in Scotland are as follows:

1. In Ayrshire, at Kilmaurs "peaty clay," "pre-glacial" (Bryce), "Inter-glacial" (Geikie).

2. Between Edinburgh and Falkirk.

3. Chapel Hall in Lanarkshire, and Bishopbriggs.

[1] Not stated whether dredged or from dry land.

4. At Clifton Hall.

In Ireland, remains of the Mammoth have been found in lacustrine deposits at Belturbet in Cavan.

In Antrim, at Corncastle, "marine deposit."[1]

In Waterford, near Whitechurch (somewhat doubtful).[2]

2. *Caverns.*

The following caverns have produced remains of the Mammoth.

Devonshire, Kent's Cavern (B. M., and Mus. Torquay), Oreston (B. M.)., Beach Cave (Sanford), Brixham (Busk).

Somerset, in Hutton Cave and a Cavern, near Wells (B. M.), Wookey Hole (B. M.), Bleadon Cave (Falconer), Box Hill, near Bath (Dawkins), Durdham Down (Falconer), Sandford Hill (Dawkins).

Kent, in Boughton Cave near Maidstone (B. M., and Mus. Geol. Soc.).

Notts, in Church Hole (Dawkins).

Derbyshire, in Creswell Crags (Dawkins, Busk), Robin Hood Cave (Dawkins), Church Hole (Dawkins).

Glamorgan, in Long Hole, Spritsail Tor, Paviland (Falconer).

Caermarthen, in Coygan Cave (Dawkins).

Waterford, in Shandon Cave (Carte, Mus. Science and Art, Dublin).

3. *Submarine and Littoral Deposits.*

The coast-line and bed of the German Ocean, extending along the shores of Norfolk and Suffolk, and especially the well-known locality where the so-called "Forest Bed" is traced, presents remarkably interesting features with reference to the range of the Mammoth in Time.

This subject has been discussed by Falconer and Dawkins; the latter, in an exhaustive memoir,[3] shows that the teeth and bones said to have been derived from the Forest Bed had never been found *in sitû*, and this view is still maintained by the Rev. J. Gunn, F.G.S., who has informed me that his latest experiences give him no cause to alter his views on that head. Molars of the Mammoth have been found on the Norfolk coast, either at low water, or dredged, either alone or with teeth of *E. antiquus* and *E. meridionalis*. However, all the three have been discovered encrusted with the same description of matrix which forms a component of the Forest Bed. At the same time, as pointed out by Gunn, Dawkins, Clement Reid, and others, precisely the same mineral characters prevail in beds which overlie glacial deposits in the above situation; therefore the evidence of the

[1] Adams, 'Proc. Roy. Irish Acad.,' vol. iii (2nd series), p. 93.

[2] Harkness, 'Geol. Mag.,' vol. vii, p. 2.

[3] 'Geol. Mag.,' vol. v, p. 316.

Mammoth having lived during pre-glacial periods has not been established by the specimens from the coast of Norfolk, at all events as far as the instances hitherto recorded are concerned.

Professor Boyd Dawkins, in a communication made to the Geological Society, as late as November, 1878, recants his former opinions and returns to the belief that the Mammoth was *pre*-glacial. This view he maintains on the above-mentioned evidences from the Forest Bed and other bygone and hitherto disputed statements, supported by a discovery lately made [1] in making a boring at Northwich, in Cheshire. This latter piece of evidence is, however, like the others, faulty, from the absence of direct proofs as to, 1st. The exact stratigraphical horizon; 2ndly. The age of the deposits; and 3rdly, the mode by which the information was obtained.

Admitting, indeed, that I feel almost assured the Mammoth preceded the Ice Age, yet in all justice to facts it appears to me that this verdict stands at present "not proven." I am not aware of marine or littoral discoveries north of the Dogger Bank, which, however, has yielded to the dredge enormous quantities of bones and teeth in conjunction with relics of other Pleistocene Mammals. A large collection, made by Mr. Owles from the above situation, has been just lately acquired for the British Museum.[2] It represents almost every stage of growth from the adolescent to the aged; and the grinders, as will be noticed in the sequel, are interesting, as they accord closer with the characters of Arctic and the so-called Mammoth molars from the United States, rather than with the thick-plated tooth from the fluviatile deposits of Ilford, in the Thames Valley.

It would be tedious and unnecessary to enumerate the various points on the East Coast where remains of the Mammoth have turned up, more especially in the case of the majority of Forest Bed fossils, which are "waifs and strays," cast up and rolled about by the waves. Numbers of teeth and tusks have been dredged as far eastwards as trawlers and oyster-dredgers proceed off Yarmouth, Harwich, &c.[3] The channel of Brightlingsea has been also prolific of specimens. My distinguished friend Dr. Bree, of Colchester, has a collection made, from ten miles off Dunkirk, where, he informs me, the sea-bottom is so full of Mammalian fossils that sailors call it the "Burying Ground." The discoveries along the English Channel have not been so numerous, but teeth have been dredged on

[1] 'Geol. Soc. Abstracts and Proc.,' No. 357, p. 2.

[2] Davies, 'Geol. Mag.,' vol. v, p. 77. The National Collection now contains, perhaps, the most extensive assortment of extinct proboscidean remains ever brought together under the same roof. This I feel amply justified in stating, from personal observation, has been owing in no small degree to the discernment of my friend Mr. W. Davies, F.G.S., whose intimate knowledge of fossil zoology is always at the service of whomsoever seeks for information in the galleries under his immediate supervision. I, therefore, who have oftentimes been benefited by his accurate and painstaking discriminations, take this opportunity of recording the valuable assistance I have received from Mr. Davies in the working up of the materials for this Memoir and my previous Monograph on the *Elephas antiquus*.

[3] 'Brit. Fossil Mammals,' p. 246, *et seq.*

a submerged forest as far west as Torquay,[1] in Devonshire. A mandible with molars is in the British Museum, from the Harbour of Holyhead;[2] and I lately was shown by Mr. Davies a humerus obtained by the Earl of Enniskillen from the Bay of Galway, which is the most western point in the European distribution of the species.

FOREIGN DISTRIBUTION.

The Mammoth has left its remains in the valley gravels and many caverns throughout France,[3] and has been traced to Northern Spain.[4]

Dr. Falconer identified molars from the neighbourhood of Rome and northwards towards the Alps. Its remains have turned up in Switzerland, Austro-Hungary, Germany, the Netherlands, Holland, and Central and Northern Russia,[5] but not, as far as I am aware, in Denmark, Norway, nor Sweden. The identity of the species whose remains have been discovered in the Crimea, Odessa, Black Sea, and Bosphorus, together with the so-called *E. Armeniacus*, from Turkey in Asia, requires further investigation.[6] The close affinities of molars of the latter with those of *E. Asiaticus*, on the one hand, and *E. Columbi* on the other, require more extended comparisons.

The South-European extension of the Mammoth is far greater than its cuticular covering has led naturalists to suppose. Falconer has confirmed its presence from deposits around Rome, and I have examined molars from near Santander in Spain; but, excepting the somewhat doubtful molar referred to in the sequel, from the Black Sea, I know of no instance from the lands or islands of the Mediterranean area, and its eastward extension.

The continual discoveries of remains along the shores and river-valleys of Siberia, Behrings Straits, and Alaska, are too well known to need me to make special records of these localities. Until just lately European palæontologists, reasoning from the following data, believed that the Mammoth had been traced as far south as Texas. But Professor Marsh, who informs me that his authority for the following statement is Dr. Leidy, states that "this species does not appear to have extended east of the Rocky Mountains, or south of the Columbia River, but was replaced there by the American Elephant, which preferred a milder climate. Remains of the latter have been met with in Canada, throughout the United Sates, and in Mexico."[7] Notwithstanding this

[1] Lyell's 'Principles of Geology,' vol. i, p. 544.

[2] Ib., vol. i, p. 545.

[3] Cuvier, De Blainville, Lartet, Lortet, Chantre, &c.

[4] Adams, 'Journ. Geol. Soc. Lond.,' vol. xxiii, p. 537.

[5] See Falconer's essay "On Range of Time and Earliest Headquarters of the Mammoth," 'Pal. Mem.,' ii, 239, &c.; 'Geology of Russia,' vol. i, p. 492.

[6] Demidoff, 'Voy. dans la Russie Méridionale,' vol. ii; Falconer, *op. cit.*

[7] "Introduction and Succession of Vertebrate Life in America. An address delivered before the

statement, Orton refers to Mastodon and Mammoth remains having been found associated in an old forest-bed, some twenty to forty feet below the present level of the Ohio.[1] This opinion resolves itself into a matter of careful observation, so that unless critical attention had been paid to the study of Elephantine remains, associated with much practical experience in the manipulation of specimens, the molars of *E. primigenius* might have been mistaken for those of its ally, the American Elephant.

The question as to the North-American distribution of the Mammoth would, therefore, appear at present not to be precisely determined; it seems necessary, therefore, to refer more fully to the materials on which European palæontologists have based their conclusions. Cuvier, Owen, De Blainville, and Falconer confirm each other's diagnosis from the specimens in the Institute of France, British Museum, Museum of the Royal College of Surgeons of England, and Woodwardian Museum, Cambridge, and I have carefully, with the exception of the French, examined all the specimens. They are said to be from various parts of the United States, to wit, Ohio (Big Bone Lick), Kentucky, Missouri, Carolina, and Texas.

All show precisely the same mineral characters, being black and deeply stained like the remains of Mastodon from Ohio, just as if they had lain long in peat. The dental characters are precisely similar to, and indistinguishable from crowns of Arctic molars, that is, they display the very *thin* enamel and *crowded* discs which, with few exceptions, characterise the molars from Northern Asia and Arctic America.

Now, if a fraud had been practised, it must have been extensive, from the great numbers of specimens in the English and French museums. Moreover, the donations to the French Institute, we are told by Cuvier, were made by the President of the United States,[2] but the English specimens seemed to have been acquired by purchase.[3]

The discovery, in 1863, in "sand and gravel" at Hamilton, on the banks of Lake Ontario, of molars and mandibles of Elephants has been referred to by Mr. Billings and by Falconer.[4] The former arrived at an opinion that the species was distinct from

American Association for the Advancement of Science, 1877." Dana is of opinion that the Canadian Elephant was the Mammoth—'Manual of Geology,' p. 563.

[1] 'Report on the Geol. Survey of Ohio,' vol. i, p. 428. It is possible, however, that this Elephant may have been *E. Columbi*.

[2] 'Ossemens Fossiles,' vol. ii, p. 148, pl. xv, figs. 9 and 11.

[3] I am indebted to my friend Professor Flower, LL.D., for the following record relating to the purchase of the specimens for the Museum of the Royal College of Surgeons of England. A printed list is preserved in the Library of the College of the sale, which took place at Stevens's Auction Rooms in the year 1835. Referring to the Elephant's teeth and bones it is stated that the "bones were said to be found twenty-two feet below the surface at Big Bone Lick, in Boone County, State of Kentucky, in the autumn of 1830, dug up by B. Finnel and others. Big Bone Lick lies back from the Ohio River about ten or twelve miles, and about sixty miles below Cincinnati. Brought from North America by Mr. Inghan, of Kentucky."

[4] 'Geological Survey of Canada,' p. 914, figs. 495 to 498; Falconer, 'Pal. Mem.,' vol. ii, 239.

the Mammoth on account of the chin being narrower, whilst the teeth resembled the crown of the latter.

As far as the indifferent representations of these teeth will permit me to judge, the molars and mandibles seem indistinguishable from the same parts of the Mammoth, the symphysial junction of whose rami, as will appear in the subsequent woodcuts, is not always of the truncated and rounded character usually distinctive of the typical lower jaw. The thin parallel plates also consort with crowns of that species. The same might be said of three rudely executed representations of mandibles and molars under the name of *E. Jacksoni*.[1]

The distribution, therefore, of the Mammoth in North America, as defined by Marsh and Leidy, is quite opposed to that indicated by the reputed remains from the United States in European collections, and I must admit, without prejudice to either view, that although the specimens I have examined bear striking resemblances in external coloration to Mastodon remains from the swamps of Ohio, they likewise resemble, in that respect, specimens from the frozen soil of the Arctic regions, and still more so in their closely packed and attenuated ridges. I must leave the subject, therefore, of the North American distribution of the Mammoth for further confirmation. A Monograph on the fossil Elephants of North America, compiled from specimens in museums and private collections, is, indeed, a desideratum which, it is hoped, the able and indefatigable palæontologists of the New World will not defer much longer.

Associated Mammals.

Reference has been made in my Monograph on *E. antiquus* to the British localities where remains of the Mammoth have been associated with the latter species;[2] the only difficulty at present is the contemporaneity of the Mammoth with *E. meridionalis*. I am not aware of one instance of the relics of these two Elephants having been found together on the Continent of Europe or elsewhere, whilst their so-called contemporaneity, as far as the British Islands are concerned, requires apparently further confirmation. The Mammoth has been found associated with nearly all the British Post-tertiary and many of the Recent Mammals.[3] It survived up to the Stone Age in England and on the Continent of Europe.[4]

[1] Silliman's 'American Journal,' vol. xxxiv, p. 363.

[2] Page 6.

[3] Dawkins, 'Quart. Journ. Geol. Soc. London,' vol. xxv, p. 194.

[4] Dawkins, 'Quart. Journ. Geol. Soc.,' vol. xxxiii, p. 590. The famous etching on the fragment of a tusk in the care of La Madelaine in the Dordogne (see *Reliquiæ Aquitanicæ*, also British Bone Caverns, &c.).

III.—DENTITION.

The differentiation of three species of Elephants from remains found in the fossil state in Great Britain was not fully admitted until the labours of the late Dr. Falconer, F.R.S., became generally known. Professor Owen, whilst impressed with the remarkable differences in the dental characters of remains referable to the *Elephas primigenius*, was not then (1846) prepared to consider them as indicative of more than one species.[1] The precise descriptions and beautiful illustrations of the varieties of molar teeth represented in the work of that illustrious comparative anatomist could not otherwise than arrest the attention of palæontologists, and of all others the distinguished naturalist above mentioned, whose famous discoveries in the Sewalik Hills had made him familiar with the dentition of extinct Proboscidea.

The remarkable essay published by Dr. Falconer on the Species of Mastodon and Elephant occurring in the Fossil State in Great Britain was commenced in 1857,[2] but he did not live to complete the latter part, referring to *Elephas primigenius*, and the entire description of *Elephas antiquus* is wanting.[3]

Every student of extinct forms of animal life is familiar with Falconer's classification of the Proboscidea, based on the characters of their molar teeth, and of his methods of constructing the ridge-formulæ characteristic of the various sub-genera and species. The terms "isomerous," "anisomerous," and "hypisomerous," used by him to distinguish the specific characters, although not advanced as mathematically exact in every case, being, as the author states, "liable to vary within certain limits dependent on the race, sex, and size of the individual, but it may safely be asserted that the numbers are never transposed or reversed, *i. e.* the younger tooth among the 'intermediate molars' never normally exhibit in the same individual a higher number than the older."[4] As an example, in the members of the sub-genus *Euelephas*, and notably the *Elephas primigenius* and *Elephas Asiaticus*, the ciphers of whose molars, he states, are precisely alike in number, he formulates their ridges in upper and lower teeth thus :— 4+8+12 :: 12+16+24, showing that, with the exception of the first and ultimate true molars, the others increase by increments of 4, or, as he terms it, by an "anisomerous mode of progression." But, as will appear in the sequel, it is by no means easy to determine what ciphers should even fairly represent the average number of ridges in certain

[1] 'British Fossil Mammals,' p. 243.

[2] 'Quart. Journ. Geol. Soc. of London,' vols. xiii, xiv, and xxi.

[3] In the 'Palæontological Memoirs' of the late Dr. Falconer the editor has appended certain "note-book entries" to the end of the essay on *Elephas primigenius*.—'Pal. Mem.,' vol. ii, p. 172.

[4] 'Pal. Mem.,' vol. ii, p. 10.

members of the dental series, the range of variability being often so great that the average of a given number of specimens is no reliable exponent of the numbers and variations to which the tooth is subject.

A similar conclusion was come to by me with reference to the dental series of *E. antiquus;* and therefore, as in the latter case, I am compelled to believe that the only true method of expressing the ridge-formula of elephantine molars is by giving the minimum, mean, and maximum number of ridges of each member of the dental series.

Therefore, Dr. Falconer's method of demonstrating the ridge-formulæ of his sub-genus *Euelephas* by progressive increments of 4, or anisomerous ciphers, seems to me both arbitrary and dogmatical. It is, in fact, too absolute a method, and is at variance with the laws of mutability of species, which advancing knowledge shows is far greater than has been supposed.

In the Synoptical Table of the Species of Mastodon and Elephant Dr. Falconer distinguishes the worn crowns of molars of *E. primigenius* from the teeth of all other known living or extinct species thus:—"Colliculi confertissimi, adamante valde attenuato, machæridibus vix undulatis."[1]

Cuvier had previously established broad marks of distinction between the molar of the Mammoth and that of the Asiatic Elephant, with whose skeleton generally he had noted certain well-marked affinities. But although more experienced than, perhaps, any of his contemporaries and predecessors, as far as the manipulation of remains of extinct Elephants was concerned, he applied the specific name of *Elephas primigenius* to all the fossil Elephant remains discovered in his time, and previously, in Europe, Arctic Asia, and North America. It is but justice, however, to his great name, and also to the credit of several of his successors, to remember that the light which shone dimly on them by reason of scanty data shines now brightly on account of the enormous amount of materials accumulated even since the publication of the 'British Fossil Mammals.'

The molar crown of the Mammoth is distinguishable from that of other and allied species by the—1, great breadth of the crown as compared with the length; 2, the narrowness of the ridges; 3, the crowding or close approximation of the ridges; 4, the tenuity of the enamel; 5, the absence of crimping.[2]

These characters combined suffice to distinguish the grinder from that of its near allies, such as of the *E. Asiaticus*, *E. antiquus*, and *E. meridionalis*.

With reference to (1) the great breadth of the crown. This character, although also present in *E. meridionalis*, is distinctive of the Mammoth as compared with the other two species, to which may be added the *Elephas Columbi*, with whose remains it is said to

[1] 'Quart. Journ. Geol. Soc. Lond.,' vol. xiii, p. 319; also 'Pal. Mem.,' vol. ii, p. 14. As in the case of *Elephas antiquus*, I shall refer to these essays in his Memoirs, for the reason that they are published together, and are, therefore, more convenient for reference.

[2] I have adopted the same terms used in my Monograph on *Elephas antiquus*. All enamelled laminæ, whether plates or talons, are indiscriminately named *ridges*. A colliculus is an *unworn ridge*. The letter *x* stands for *talon* as opposed to *plate*.

have been found associated in North America, and also with *Elephas Armeniacus*, which is closely allied, if not identical in its dental characters, with *E. Columbi* and *E. Asiaticus*. The affinity between the Mammoth and certain Miocene (?) Sewalik species will be referred to in the sequel. According to Falconer, it belonged to the "EURYCORONINE" series of his sub-genus EUELEPHAS.

(2.) The narrow ridges of the Mammoth's molar are peculiar as compared with its allies, and are usually parallel, more or less, although they may be sometimes rather bent, as seen in Plate XI, fig. 2, but rarely to the extent observed in *E. antiquus*.[1] The above character is best seen on the worn crown. The disc has not the central dilatation and angulation of that of the latter species, and its outline is more even than in either the Asiatic or Meridional Elephant. Falconer truly observes that the enamel plates "in *E. primigenius* are only half as thick as in *E. meridionalis*, and thinner than in the Indian Elephant or in *E. antiquus*."[2]

(3.) The close approximation of the ridges is a marked feature of the Mammoth's teeth. The cement wedges without are smaller, just as is the dentine within the ridges. The above point of distinction is ordinarily characteristic *per se*. The digitations of the unworn ridge or *colliculus* are numerous, but never so large and massive as in *E. antiquus* and *E. meridionalis*. They are greatly lengthened sometimes, as seen in the worn crown (Pl. VIII, fig. 2).

(4.) The enamel of the molar of the Mammoth is relatively thinner than in any other known species, but there is considerable variability, as will appear in the sequel. It is remarkably attenuated in teeth from the Arctic regions, and the so-called Mammoth teeth from the United States, also in molars from certain districts in the British Islands and Continent of Europe, to be noted presently, whilst the reverse obtains from remains discovered at Ilford, in the Thames Valley, and elsewhere, as first pointed out by Davies;[3] but these extremes may be found in teeth from the same localities, and even the same deposits. The enamel has a tendency apparently to become thick in the penultimate and ultimate true molars, and apparently so in individuals and in small teeth containing the lowest ridge-formula of the individual member of the series, whatever it may be. Consequently age, and perhaps sex, besides individual peculiarities, may have a good deal to do with either extreme. The terms, therefore, THICK- and THIN-plated so characteristic of the teeth of *E. antiquus* and the Maltese fossil Elephants,[4] indeed, as will appear hereafter, also in *E. meridionalis*, although not so pronounced as in the two former, are present also in *Elephas primigenius*. The advantages of narrow bands of enamel to the Arctic individual, as compared with the broader ridges of the crowns of teeth from the Thames valley deposits, might furnish matters for speculation in connection

[1] Pl. I, fig. 4, Monograph.

[2] 'Pal. Mem.,' vol. ii, 146.

[3] 'Trans. Zool. Soc. Lond.,' vol. ix, p. 7; 'Cat. Brady Collection,' p. 4.

[4] Op. cit.

with the probable food of the denizens of the two regions, and the results of natural selection. How far a race character can be determined on one or other conditions I am not at present prepared to say, but with the view of arriving at some conclusion on this head I have carefully attempted to determine the relative thickness of the ridges in a large number of molars from British and foreign localities with the following results :[1]

All the teeth from Kent's Cavern, Devonshire, show the Arctic type, and have *thin* enamel. In two molars from Brighton, in the British Museum, one from "gravel" is *thin*-plated, whilst another from a "raised beach" (?), and in Mantell's Collection, is *thick*-plated. It might be asked were these two deposits contemporaneous ? In the National Collection the following localities have produced Mammoth molars with *thin*-plates :—No. 27,908, railway-cutting Ipswich ; No. 47,122 Kettering, Northamptonshire ; No. 41,081, Isle of Dogs, "in peat ;" and Fenny Stratford, in Bucks ; also Lexden, in Bucks, "in peat ;" at Lamarsh, a railway-cutting in the Stour Valley, furnished three molars, and which are now in the British Museum. One tooth has *thick* enamel, and in two it is *thin*. With one exception, and that is in the mandible referred to at p. 108, all the Dogger Bank molars are *thin*-plated. So numerous are Mr. Owles' gatherings in the British Museum that no less than twenty-four ultimate true molars of the Mammoth are represented.

A tooth from a "raised beach," Pl. XI, figs. 1 and 1*c*, in Bracklesham Bay, is very *thin*-plated.

Falconer refers to a *thin*-plated molar from the Mendip Caves ;[2] there is a similar tooth from a cavern near Wells, Somersetshire, in the British Museum, and another from Hinton, in the same county, in the Museum of the Royal College of Surgeons ; a tooth in the National Collection, from Wookey Hole, is also decidedly *thin*-plated, as seen in Pl. X, figs. 3 and 3*a*. It is, however, only a penultimate milk-molar, and may be considered as scarcely characteristic.

The molars dredged up on the East Coast of Norfolk are, for the most part, *thin*-plated, but specimens from Harwich and Cromer, in the British Museum, have *thick* enamel. Their exact stratigraphical positions, however, are uncertain. The teeth from Ilford, as shown by Davies, not only represent a small form or race, but are unexceptionally *thick*-plated, whilst those from Crayford and Erith, on the opposite side of the river, are *thin*-plated ; and whilst a *thick*-plated tooth is represented by a molar from the river deposits of the Thames under Pall Mall, in London, the other extreme is well shown by Pl. XIV, fig. 1, from Millbank, higher up, and others from Thames river deposit at Battersea, Clapton, and from Oxford gravels ; the last named are

[1] It is of importance in calculating the actual thickness of the plates and space occupied by each to take the measurement at the enamel reflections, as the ridges have a tendency to bend towards one another about the middle of the molar. The enamel, on the other hand, is generally thickest about the middle of the plate.

[2] 'Pal. Mem.,' vol. ii, p. 172.

represented by numerous instances in the Museum of the University. The smallest ultimate molar of the Mammoth I have seen is *thick*-plated. It is that shown in Pl. XIII, figs. 1 and 1*a*, from KIRBY, in Leicester. Several molars from DUNKIRK, Northern and Central FRANCE, GERMANY, AUSTRIA, and the DANUBE, in the British Museum and Woodwardian Museum, Cambridge, are decidedly *thin*-plated, whilst one from Moscow, in the former, has *thick* enamel.

Now, although apparently not much reliance can be placed on the state of the enamel as characteristic of race, at the same time the Arctic or typical crown represented by the North-Asiatic and North-American specimens, on the one hand, and Kent's Cavern on the other, presents a decided contrast to the molars from Ilford on the Thames, where not only is the enamel thicker, but the teeth themselves are all much smaller. The same character, as will be shown in the sequel, obtained in other parts of the skeleton, so that we are, at all events, fairly justified in concluding that many small-sized individuals sojourned in the Valley of the Thames during the deposition of its sands, clays, and gravels, whilst the Leicester molars represent what must have been a *dwarf Elephant* scarcely larger than the *Elephas Mnaidriensis* of Malta. Altogether these facts prove much variability in dimensions of full-grown individuals.

(5.) The external or outer surface of the flattened enamel of the plate of the Mammoth grinder may be either smooth or rough, to the extent that the plane of detrition presents an even edge or slightly crimped border, the latter character being generally pronounced towards the middle of the plate. Indeed, the *rugæ* on the outer surface may be scarcely defined, or so prominent that a transverse section presents the above character. These variations may be noticed in individual discs of the same molar and are well represented in the Plates. The outline of the enamel disc is usually even, but occasionally undulating, and the inner surface of the plate is smooth. As to the degree of crimping of the machærides, in comparison with allied forms, it is not nearly so pronounced as in the *Elephas antiquus*, in which the crimping or festooning involves the entire thickness: this is not generally the case in the former, the roughening being generally confined to the outer edge of the enamel. The excessive crimping in the Asiatic Elephant is a marked character of its molar, and although there may be no such appearance of the enamel in the tooth of *E. meridionalis*, it is readily distinguished from the Mammoth's, by the thickness of the enamel, excess of intervening cement, and other well-developed points, which will be fully noted hereafter.

With reference to the other crown constituents, to wit, the dentine and cement:—An excess or a diminution of the former does not present a remarkable feature in the molar of the Mammoth. As usual in all species, the dentine of the base and the cement increase in quantity with the age of the tooth; that is, the common base is augmented as the ridges are being ground completely down, and attains to considerable thickness in ultimate molars, as in examples which will be referred to. The cement also increases

in quantity in much-worn last true molars, occupying often, as in the mandible (Pl. VIII, fig. 3), a considerable space between the enamelled ridges and socket, so as to keep the tooth steady, as it has no successor and must carry on the mastication to the death of the animal.

1. INCISORS.

There is no record, as far as I know, of the discovery of the Milk Incisor of the Mammoth. It may, as occasionally obtains in the recent species, have been diminutive and often deformed, and was shed very early to make room for the ponderous permanent tusk.

The slight divergence in the alveoli, from the root to the margins of the pre-maxillary, will be noticed with the cranium.

The direction of the tusk on leaving the jaw is, as in the Asiatic and African Elephants, downwards, outwards, and finally upwards, with the tips directed *inwards*, presenting a strange contrast to that of *E. ganesa*, where the tusks may be said to converge in their sockets, then become *parallel* to near the tips which curve *outwards*.[1] The tips, therefore, of the tusks of the Mammoth curve inwards like in the recent species, as demonstrated by Mr. Davies, in the Ilford cranium, Plate VI, fig. 1*a*; indeed, to his careful manipulation at the exhumation is owing the preservation of this precious relic, which is the only cranium of the Mammoth anyways entire, hitherto recovered from the Pleistocene deposits of the British Isles.[2]

The direction of the tusk, although generally spiral, especially in old males, appears to have constantly assumed various degrees of curvature, from almost a perfect straight defensor to nearly a complete circle. Sometimes it was remarkably slender. It was doubtless present in both sexes, the smaller and more attenuated being likely that of the female.

The contrast between the incisor and the cranium, as represented in Pl. VI, fig. 1 *a*, is remarkable, and shows their disproportionate dimensions. Although the generality of tusks from the Arctic Regions exceed in size the majority met with in the British Isles and Europe, at the same time, comparisons between the former and the latter, as presented by the collection in the British Museum and elsewhere, show instances from British strata of the tusk attaining to as large a size as any from Siberia, or Boreal North America. This is well shown by a colossal specimen in the last-named collection, found with the huge last molar, Pl. IX, fig. 2, at Fenny Stratford near Spalding in Lincolnshire, and which will be referred to in the sequel.

The measurements of tusks are unimportant; besides, few specimens are perfectly entire. The disposition towards a spiral direction is decidedly more evident in the

[1] See 'Fauna Antiqua Sivalensis,' pl. xxiii. This magnificent specimen is placed behind the Ilford cranium of the Mammoth in the British Museum to show their cranial contrasts.

[2] 'Geol. Mag.,' vol. ii, p. 239, and Mr. Woodward's description, vol. i, p. 244, and vol. v, p. 540.

incisor of the Mammoth than that of any other known species, and seemingly on that account there is reason to admit the peculiarity as a character of the species. The tusks of *E. meridionalis*, and as far as is known of *E. antiquus*, do not appear to have exceeded the gentle curve of the recent Elephants. I repeat, however, a statement made previously, that, considering the vast quantities of teeth of *E. antiquus* discovered in British strata, no entire tusk different in curvature from that of the Mammoth has, as far as I know, turned up.

Exceptions occasionally occur at Ilford and elsewhere of nearly straight tusks; in proportion, however, to the numbers of molars of *E. antiquus* there are not only few remains of tusks, but these when at all entire show the arcuation of that of the Mammoth; the only instance I know of to the contrary is that referred to by Falconer, from Bracklesham Bay.[1] There is also a probability that the defensor may not have been developed to the same extent in the latter species, just as in the Cingalese as compared with Continental varieties of *E. Asiaticus*.

2. MILK MOLARS.

The Pre-ante-penultimate or First Milk Molar (?).

The existence rarely of a tooth so named in the mandible of the African Elephant rests, as far as known to me, on one instance. The specimen is No. 708[b] of the Osteological Collection, British Museum; it comprehends an entire skull, which is stated to have been taken from a skin procured in Paris. The skin has been stuffed, and is placed in the Zoological Gallery along with other Mammals. I have before alluded to the tooth in question,[2] and both De Blainville and Dr. Falconer[3] have given illustrations of the mandible, and Mr. Busk has also noticed it.[4] It is much to be regretted that neither De Blainville nor Falconer, who had opportunities of examining the mandible soon after its extraction from the skull, have furnished precise details beyond figures. As the specimen now stands it is extremely difficult to understand how the three teeth fitted into the space they now occupy in the left ramus. A large portion of the inner wall of the horizontal ramus has been cut away, and the septum between the penultimate and ante-penultimate has been also removed, whilst the first and second molars are jammed so close together that absolutely their fangs cross one another, so as to make it clear that

[1] See my 'Monograph on *E. antiquus*.'

[2] "Dentition of *E. antiquus*," 'Monograph,' p. 11, and "Dentition of the Maltese Elephants," 'Trans. Zool. Soc. Lond.,' vol. ix, p. 10.

[3] 'Ostéographie,' pl. xiv, fig. 4; 'Faun. Antiqua Sival.,' pl. xiv, fig. 4; and 'Pal. Mem.' (Falconer), vol. ii, pp. 89 and 441, and *Corrigenda*.

[4] 'Trans. Zool. Soc. Lond.,' vol. vi, p. 287.

they could not have had separate alveoli. Again, neither in extent nor in direction of wear do the planes of detrition of the upper and lower jaws, left side, agree. The extent of worn surface of the two teeth on either side of the maxilla is 46 millimètres, but it is 60 millimètres on the left lower jaw and 40 on the right, so that the *pre*-ante-penultimate tooth does not seem to have had an opposing grinder, although its crown, as may be seen in De Blainville's plate iv, fig. 1, is more than half detrited. Further, the tips of the collines of the penultimate of the left lower ramus should present fewer abrasions than those of the right side from the additional tooth in front; but this is not so, the two being equally detrited. De Blainville's figure shows three well-marked septa between the teeth of the left ramus, none of which, however, remain in the specimen, excepting a remnant of the one in front of the penultimate; besides, the ante-penultimate tooth of the right lower ramus is now wanting. Altogether, the specimen is at present hopelessly useless as an exponent, *per se*, of this so-called abnormality—a conclusion I have arrived at after a careful re-examination of the specimen in consort with my friend, Mr. W. Davies, F.G.S. It is to be desired, therefore, that all like abnormalities should be carefully described, in order to further establish the existence of this so-called First milk-molar.

Among the varied and interesting Mammalian remains discovered in Kent's Cavern, Devonshire, is the remarkably diminutive milk-molar, No. 5774 (Pl. IX, fig. 4).[1]

In a memorandum kindly furnished me by Mr. Pengelly, F.R.S., he states that the tooth was found "on the 2nd of December, 1871, in the Cave of Rodentia, in the four-foot level of cave-earth, with one tooth of Hyæna, and bones and bone fragments." It is described by Mr. Busk, F.R.S., with his usual care and precision; and he surmises, I think justly, that it may be the *pre*-ante-penultimate milk-molar of the Mammoth.[2] It was originally entire, but a fragment of the crown has been recently lost. In dimensions this tooth is one of the smallest milk-molars of any Elephant with which I am acquainted, and is even more diminutive than the first milk-teeth of the Maltese Pigmy Elephants. It is $0{\cdot}4 \times 0{\cdot}3$ inch in breadth, the smallest from the Maltese Elephants being $0{\cdot}4 \times 0{\cdot}32$, whilst the *pre*-ante-penultimate of the African Elephant is $0{\cdot}65 \times 0{\cdot}4$.

The crown-formula of fig. 4*a*, Pl. IX, is $x\ 2\ x$. The tips of one of the digitations show signs of detrition, and the well-formed and consolidated fangs give evidence, at all events, that the animal did not die in the womb. The probability is, therefore, that this very small tooth may be a rare instance of the *pre*-ante-penultimate appearing in the lower jaw of the Mammoth, its long divergent fangs leading to the belief that it belonged to the mandible.

[1] For permission to figure this interesting object and other Mammoth remains from the above-named rock cavity I am under obligations to the Kent's Cavern Committee of the British Association, and to that laborious and painstaking cave-digger, Mr. Pengelly, whose troglodytic researches have done much to advance our knowledge of the Pleistocene fauna of Great Britain, and to systematize cave-explorations in general.

[2] 'Report Brit. Association,' 1872, p. 37.

The remarkable specimen from a cavern near Zwickau, in Saxony, described and figured by Kaup as the *Cymatotherium antiquum*,[1] is referred to by Falconer, who believes it is the *ante*-penultimate milk-molar of the Mammoth.[2] This tooth differs from the last in resembling certain molars of *E. antiquus* and the Maltese Pigmy Elephants[3] by possessing a single, connate, compressed fang, with a groove down the sides, indicating the line of partition between the fangs. It holds two plates besides an anterior and posterior talon in a length of 9 millimètres (about 0·35 of an inch), which make it even more diminutive than the Kent's Cavern specimen. The empty socket behind it, as represented in the figure referred to, indicates the position of, possibly, the ante- as well as the penultimate. This, however, is not determined. The slightly worn tips of the molars and the consolidated fang also show that it did not belong to a uterine individual. Whichever tooth it may be, it is, at all events, the most diminutive Elephant's molar with which I am acquainted.

The low ridge-formula is not a character, seeing that instances of x 2 x are not rare in other extinct, and also in the ante-penultimate milk-teeth of the recent species. But the above and the Kent's Hole tooth are so excessively small in comparison with the next molars described here, that, unless the ante-penultimate is subject to great discrepancy in that respect, and I see no reason why such should not be the case, as it prevails in the other members of the dental series, it may just be likely that they belong to the anomalous condition represented by the African mandible referred to. At all events, the single compressed and grooved fang which is sometimes present, as I have shown in the case of *E. antiquus* and the Maltese fossil Elephant,[4] occurs also in *E. primigenius*. I have seen no such instances, however, from jaws of the recent species. The above may be suggestive of possible reappearances of ancestral homologies.

Ante-penultimate or Second Milk Molar.

An excellent representative of this member of the dental series is presented by No. 1063 of the Kent's Cavern Collection, shown in Plate IX, fig. 3. It is of the upper jaw and probably of the right side. The fangs are wanting, but, as demonstrated by fig. 3, they are bifurcated, the larger (fig. 3 *c*), as usual, being the posterior. The tips of the digitations of the four anterior plates (fig. 3*a*) being slightly detrited show the owner to have been, at all events, not a uterine individual. According to Mr. Pengelly's memorandum, "it was found, 21st December, 1865, in the Great Chamber in the four-foot level of cave earth." The ridge-formula is x 4 x in $0{\cdot}8 \times 0{\cdot}6$, showing dimensions equal to the

[1] 'Akten der Urwelt,' tab. iv, p. 11, and De Blainville's 'Ostéographie,' pl. x.

[2] 'Pal. Mem.,' vol. ii, p. 161.

[3] 'Monograph,' Pl. I, fig. 2; 'Trans. Zool. Soc. Lond.,' vol. ix, pl. i, fig. 6.

[4] 'Monograph on *E. antiquus*,' p. 10, Pl. I, figs. 2, 2 *a*, and 'Trans. Zool. Soc. Lond.,' vol. ix, p. 10, pl. i, figs. 3—6.

largest of any equivalent milk-molar of the Asiatic Elephant which has come under my notice; indeed, the breadth somewhat exceeds that of the largest I have examined, and is, therefore, in keeping with the relatively greater breadth of the Mammoth tooth. The plates are *thin* as compared with those of the upper ante-penultimate of *E. antiquus* (Pl. XII, fig. 3 *a*), but are indistinguishable in that respect from specimens of *E. Asiaticus*.

The same tooth in *E. Africanus*, although generally as large, and frequently even larger, is, like that of *E. meridionalis*, easily distinguished from the Mammoth's by the thick massive plates. The ridge-formula, however, of *x* 4 *x*, as I have shown at p. 11 of my Monograph on *E. antiquus*, is found not unfrequently in upper and lower molars of the African.

With reference to the *ante*-penultimate milk-molar in *E. antiquus*, the above is a very suggestive specimen, and is now in the Museum of Practical Geology, Jermyn Street. It was presented to the Collection by the late Dr. Cotton, and is shown in Pl. XII, fig. 3, for the purpose of still further elucidating the dental succession of this species. The fragment belongs to a maxilla, and is from Ilford; it shows the ante-penultimate and penultimate milk-molars of *E. antiquus*. The former (fig. 3 *a*) contains *x* 2 *x* in a space of $0{\cdot}9 \times 0{\cdot}7$ inch, while the latter (fig. 3) holds *x* 5 *x* in 2·5 inches. The thickness of the plates and crimping of the machærides of the disks are sufficiently characteristic of *E. antiquus*, which was contemporary with the small variety of the Mammoth during the period of the deposition of the brick-earths of Ilford; and, although all the numerous evidences from this locality show that the latter greatly predominated, it is clear that *E. antiquus* was also not uncommon, and, as regards size, was decidedly the larger and stouter of the two species.

A fragment of the left ramus of a mandible from Ilford is represented by specimen No. 21,311 in the British Museum, and is shown half natural size, Pl. X, fig. 2. It displays the double fang-pits of an ante-penultimate milk-molar, with a large socket posteriorly for the successional tooth. This fragment, when compared with that of *E. antiquus*, Pl. V, fig. 2, of my Monograph, shows a relatively broader ramus, and a wider and shorter socket for the penultimate. On these grounds it seems to me, taking into consideration that both fragments represent the same stage of growth, that Pl. X, fig. 2, belongs to the Mammoth.

Dr. Falconer refers to the fragment of a mandible, No. 33,403, in the Layton Collection in the British Museum, containing "the sockets of the two anterior milk-molars."[1] It is clearly a dredged specimen from the Norfolk Coast, and appears to me to represent a more advanced stage of growth than the preceding, the sockets referred to being of the last and penultimate milk-teeth. This specimen is not, to my mind, diagnostic of any one species in particular, in consequence of being a mere fragment.

A suggestive mandible, No. 37, of the Ilford Catalogue, is shown in Plate X,

[1] 'Pal. Mem.,' vol. ii, p. 161.

figs. 1 and 1 *a*. Mr. Davies has recorded its chief admeasurements. I may observe, however, that there is only *one fang-pit* for the *ante*-penultimate milk-tooth. It might be inferred that the posterior was obliterated by the advancing penultimate molar, but this is rendered unlikely by the circumstance that the tips of the anterior ridges only are worn down. There is a greater likelihood, therefore, that the ante-penultimate tooth had one connate fang, like the Saxon specimen and those already referred to. Thus, I repeat, they confirm the condition as of occasional occurrence also in *E. primigenius*.

This mandible shows a produced chin (fig. 1 *a*) and low inclination of the diasteme (fig. 1 *a*), which descends nearly perpendicularly at first, but soon declines and becomes nearly horizontal before it reaches the rostrum, which is rudimentary, thus displaying a feature of the jaw of the adult Mastodon, and repeating a character common also to the young stages of growth in *E. antiquus*, *E. meridionalis*, and the two recent species.

I am indebted to my friend, Professor Dawkins, F.R.S., for permission to figure (and print his notes on) the following specimens of *ante*-penultimate milk-molars discovered by him in the Caverns of Somersetshire and Yorkshire.

Notes on the First Functional Milk Molar of *Elephas primigenius*. By Professor Boyd Dawkins, F.R.S.

"The specimens of the very rare teeth which form the subject of these remarks were discovered in the Wookey Hole Hyæna-den in 1864, and in the Robin Hood and Church Hole Caves, Creswell Crags, Yorkshire, in 1876, in both cases in cave-earth along with[1] the remains of Hyænas, Lions, Woolly Rhinoceroses, Reindeer, Bisons, Horses, and other animals usually found in Hyæna-dens north of the Alps and Pyrenees as far as the latitude of Kirkdale in Yorkshire. They consist of four teeth:

"1. (Pl. VIII, fig. 5) right lower milk molar (DM. 2), from Church Hole Cave.

"2. (Pl. VIII, fig. 6) right lower milk molar (DM. 2), from Wookey Hole Cave.

"3. (Pl. VIII, fig. 7) right upper milk molar (DM. 2), from Robin Hood Cave.

"4. (Pl. VIII, fig. 4) right upper milk molar (DM. 2), from Wookey Hole Cave.

"*Measurements*.—Their size, as compared with the corresponding teeth of other individuals and species, may be gathered from the following table, in which, also, is placed the ridge-formula.

[1] Boyd Dawkins, 'Cave Hunting,' p. 295; 'Quart. Geol. Journ. Lond.,' August, 1877, p. 590, *et seq.*

" *Comparative Measurements of Milk Molars* (2) *in the Fossil Elephants.*

	Ridge formula. Talons *x*.	Length (inches).	Breadth.	Circumference of crown.	Circumference of neck.
First Lower Milk Molars (DM.2).					
Elephas primigenius.					
No. 1. Plate viii, fig. 5	*x*, 3, *x*	0·5	0·45	1·6	1·3
No. 2. Plate viii, fig. 6	*x*, 3, *x*	0·625	0·5	1·95	1·5
E. antiquus.					
Leith Adams, Foss. Eleph. Pal. Soc., pt. i, p. 11	*x*, 3, *x*	0·7	0·4		
E. meridionalis.					
Falconer, Pal. Mem., ii, p. 114	*x*, 3, *x*	0·7			
E. Mnaidriensis.					
Leith Adams, loc. cit.	*x*, 3, *x*	0·6	0·4		
— —	*x*, 3, *x*	0·55	0·3		
First Upper Milk Molars (DM. 2).					
E. primigenius.					
No. 3. Plate viii, fig. 7	*x*, 4, *x*	0·75	0·6	2·2	
No. 4. Plate viii, fig. 4	*x*, 4, *x*	0·78	0·63	2·2	2·0
Busk, Trans. Zool. Soc., vi, p. 307	4, *x*	0·8	0·7		
E. antiquus.	*x*, 3, *x*	0·95	0·75		
Leith Adams, loc. cit.	*x*, 2, *x*	0·8	0·7		
— —	*x*, 3, *x*	0·9	0·7		
E. meridionalis.					
Falconer, Pal. Mem., ii, 110	*x*, 3, *x*	0·95	0·75		
E. Mnaidriensis.					
Leith Adams, op. cit.	*x*, 2, *x*	0·5	0·4		
— —	3, *x*	0·4	0·32		

" *Description of* DM. 2.—The two specimens of the lower first functional milk-molar of the Mammoth consist of a crown just coming into wear (Pl. VIII, fig. 5) and a tooth

with the crown worn and the fangs well preserved (figs. 6, 6 *a*). In both the crown is composed of three ridges (figs. 5 *a*, 6 *a*) and two talons. In fig. 5 the ridges are connected together by a longitudinal secondary ridge on the inner, while they are perfectly free down to their confluent bases on the outer side. The inner side of the crown presents an arc in longitudinal section, while the outer is nearly flat, the widest portion being behind (fig. 5 *b*) and the narrowest in front. In fig. 5 *c* the fangs are undeveloped. In fig. 6 *a* the crown is so embedded in enamel that its structure is only suspected by a minute comparison with the preceding tooth. It is supported on a stout bony pedestal composed of two connate fangs, which branch off at a distance of 0·95 inch from the top of the crown at acute angles to each other, the front being the smaller, as in the case of the corresponding tooth in the closely allied Asiatic Elephant. I do not, however, attach any great importance to this character, since I find the variations in the development of fangs in living and extinct Mammalia very great, and especially in the milk-molars. The total length of fig. 6, from the posterior fang-tip (broken) to crown, is 1·7 inch. As may be expected, the ridges are smaller and the enamel thinner than in the corresponding teeth of *E. antiquus*.

"The first upper functional milk-molar is proved by these two specimens (figs. 7 and 4) to have been composed of four ridges and two talons. They are both unworn, and are supported upon a base of connate fangs, proved, by the constriction shown in 3 A, to have been two in number and the front being the smaller, as in the lower jaw. The ridges are not so coarse as in *E. antiquus*, and are four in number, as compared with the three of the latter species.

"These specimens fill a blank in the history of the dentition of the Mammoth, defined by Dr. Falconer. The rest of the milk-teeth, of which some hundreds have passed through my hands, offer no characters of sufficient importance to be described.

"August 25th, 1878."

A comparison between the dimensions of the foregoing molars and Pl. IX, fig. 3, from Kent's Cavern, attests the varieties in size to which these small teeth were subject in the Mammoth; whilst, on the other hand, their general agreement in possessing narrow plates, as compared with similar teeth of *E. antiquus*, *E. meridionalis*, and *E. Africanus*, and their affinities to the crown of the *E. Asiaticus*, from which they differ again in greater breadth, fully support characters distinctive of molars of *E. primigenius*.

Prof. Boyd Dawkins's specimens represent four individuals; and whilst in Pl. VIII, figs. 5, 4, 7 belonged to newly born Elephants, as indicated by unworn ridges and undeveloped fangs, fig. 6, by its well-worn crown embedded in cement and fully developed roots, shows that the owner had been browsing, and the pressure scar (fig. 6 *b*) on the heel proves that the penultimate milk-tooth was in part invaded. Although the fangs are absent, or rather undeveloped, in the others, it will be observed, at all events

in figs. 7 *c* and 4 *c*, that they were divergent, the same being not so apparent in fig. 5 *c*, which from its smaller size may have had a single fang only.

All these molars are extremely interesting, seeing that they complete the entire molar series of the Mammoth, and must, in consequence, be considered a valuable addition to Proboscidean odontology.

Affinities.—The *ante*-penultimate milk-molar in *E. Asiaticus* varies in the number of its ridges, but in no instance of many I have seen was the ridge-formula under *x* 3 *x*; it is not unfrequently *x* 4 *x* in either jaw. The plates are attenuated, like those of the Mammoth, but the enamel is deeply crimped. Its dimensions are not smaller, as compared with those of other species,[1] whilst it agrees in ridge-formula with that of the Mammoth.

From *E. antiquus* (Pl. XII, figs. 3 and 3 *a*) the upper-jaw teeth will, I apprehend, distinguish themselves always by a higher ridge-formula and less thickening of plates—characters which are still more apparent in the teeth of *E. meridionalis* and *E. Africanus*.

The Third or Penultimate Milk Molar.

This tooth is plentiful in cavern and river deposits, but its small size prevents it being dredged with the larger members of the dental series. There is great sameness in dimensions of upper third milk-teeth of *E. primigenius* especially, more so perhaps than in any other species whose molars have been collected in equal numbers. The penultimate may be often mistaken for that of *E. antiquus*, more especially mandibular specimens. The ridges vary considerably in number. Falconer[2] sets down the formula at *x* 7 *x* to *x* 8 *x*, and Owen makes a similar statement,[3] but does not indicate whether or not the talons are included. A large proportion of British and foreign specimens examined by me point to a belief that the majority of upper teeth hold *x* 6 *x*, and lower *x* 7 *x*; but the extremes mark a considerable range, as will appear from the following.

The largest specimen I have seen, doubtfully stated as being from the brick-earth of Ilford, is No. 582f, of the Collection in the Museum of the Royal College of Surgeons of England. It is an upper tooth, and holds *x* 9 *x* in 3·3 × 1·4 inches in width.

No. 4642, B. M. (Pl. X, figs. 3 and 3 *a*), from Wookey Hole in the Mendip Hills, displays the broad crowns with *thin* enamel, somewhat crimpled towards the middle, but there is no *central expansion* or *angulation* of the disk as in *E. antiquus*. The oblique anterior, double middle, and large single posterior fang (fig. 3*a*), are represented fractured;

[1] 'Monograph on *E. antiquus*,' p. 12.

[2] 'Pal. Mem.,' vol. ii, p. 159 to 163.

[3] 'Brit. Foss. Mam.,' p. 223. The Kirkdale specimen here referred to, fig. 87, was afterwards shown by Falconer, 'Pal. Mem.,' vol. ii, p. 179, to belong to *E. antiquus*.

they always indicate a well-worn crown whose plane of detrition shows in the above six disks, with the anterior and posterior talons nearly obliterated.

The fangs in some upper teeth present considerably larger dimensions. A specimen lately obtained in the river-gravels during excavations in Oxford, connected with the main drainage works, shows a ridge-formula of *x* 6 *x* in $2\frac{1}{4} \times 1{\cdot}1$ inch. It has a broad anterior fang of $\frac{3}{4}$ of an inch in width, followed by a long narrow root, which rises from the middle and inner side of the crown, and a posterior fang of about the same size as the anterior.

A good illustration of this tooth is seen in No. 44,734, B. M. (Pl. VI, figs. 2 and 2 *a*). It is a lower molar from Hutton Cave, and, as far as the stage of dentition is of value in determining the thickness or otherwise of the enamel, it is decidedly *thick*-plated. It holds *x* 7 *x* in $2{\cdot}6 \times 1{\cdot}3$ inch, and is equalled by another specimen of the upper jaw from the same locality, which contains *x* 6 *x* in $2{\cdot}5 \times 1{\cdot}4$. In both eight ridges are contained in a space of about two inches.

In the collection of milk-molars belonging to the Kent's Cavern Museum there are ten penultimate deciduous teeth, four of which belong to the upper jaw. The upper molars are noted as follows:—"No. $\frac{11}{5379}$ was found on the 8th of September, 1870, in 'Smerdon's Passage,' in the one-foot level of cave-earth, with two teeth of Hyæna, three of Horse, two of Rhinoceros and one of Deer, three of Badger, besides bones and fine fragments." It is a crown with the six anterior ridges invaded, and holds *x* 6 *x* in $2{\cdot}2 \times 1{\cdot}3$.

Another crown, more than half worn, No. 315, was found 23rd June, 1865, in the Great Chamber, in the four-foot level of cave-earth. It holds *x* 6 *x* in about the same dimensions. The enamel is rather thicker in this specimen than in the generality of Kent's Cavern molars, but milk-teeth vary in these respects, and are not of diagnostic importance in respect to thickness or thinness of the enamel. The same formula and dimensions are presented by the still more detrited crown No. $\frac{16}{4817}$, from the same depth, in the "North Sally Port, with five teeth of Hyæna, five of Horse, two of Rhinoceros, and one of Lion." The fourth example, No. 5968, is from the "Long Arcade, in the three-foot level of cave-earth, with five teeth of Bear."[1]

The lower-jaw specimens from Kent's Cavern represent various stages of growth, and differ considerably in dimensions and numbers of ridges, as will appear from the following table (see next page):

[1] See 'Report Brit. Assoc.,' 1872, p. 46. The stratigraphical positions of the others are copied from an extract sent along with the original specimens.

Number.	Ridge-formula.	Dimensions.	Disks in wear.	Thickness of plates.	Remarks.
1248	*x* 6 *x*	1·9 × 0·85	6	0·16	Great Chamber, 4-foot level, 10th February, 1866.
1059	*x* 6	1·5 × 09·5	6	0·2	Ditto ditto 20th December, 1865. The cement is denuded from the sides of both of these molars, and also portions of the enamels.
$\frac{2}{3489}$	*x* 8 *x*	2·5 × 1·4	0	0·3	Smerdon's Passage, 4-foot level, with teeth of Hyæna, Horse, Irish Elk, and Rhinoceros, October 6th, 1870.
6066	*x* 8 *x*	2·3 × 1·25	5	0·2	Long Arcade, 2-foot level, 16th January, 1873.
2677	*x* 7 *x*	2·1 × 1·3	2 to 3?	0·26	Great Chamber, 2-foot level, 4th July, 1867.
2135	*x* 7 *x*	1·9 × 1·27	9	?	Vestibule, 4-foot level, 13th February, 1867.

The molar, Plate XIII, fig. 2, shown in profile, also from Kent's Cavern, is now in the British Museum. Here *x* 6 *x* in a lower-jaw tooth is contained in 2 × 1·2 inch, the average thickness of each plate being 0·3 inch. The crown is not invaded.

The teeth in mandible No. 44,967, No. 37, Brady Collection, B. M. (Plate X, figs. 1 and 1 *a*), display crowns just invaded, and holding six plates besides two talons in 2 × 1·1 inch.

This mandible is very characteristic of the above stage of dentition of the species. The open gutter, thick horizontal ramus, low diasteme, and rather pointed chin are present, with the empty socket of the ante-penultimate in front; whilst the scarcely detrited crowns of the penultimate show that the individual was very young.

An occasional tooth may present unusual breadth of crown. Thus, I was shown by Mr. Fitch, F.G.S., of Norwich, a second penultimate milk-molar from the Norwich Coast holding *x* 6 *x* in a space of 2·7 × 2·2 inches in width. The enamel was very *thin*.

All the penultimates, like the succeeding molars from Ilford, present thicker enamel than typical crowns of the species, but they also belonged to relatively smaller individuals than represented by equivalent teeth from the Arctic regions, and by specimens from certain British localities, to which reference has been made in connection with the former condition, as I shall have frequent occasion to point out in the sequel.

From the foregoing and numerous other specimens I find the penultimate milk-molar of the Mammoth varies constantly from *x* 6 *x* to *x* 9 *x* in variable dimensions, not, however, always dependent on the number of ridges.

Affinities.—Of the affinities between this member of the dental series and that of *E. antiquus* and *E. meridionalis* there is little to add to what I have already stated in connection with *E. antiquus* at page 15 of my Monograph on that Elephant. As regards breadth of crown, there is a similarity between that of the Mammoth and *E. meridionalis*, but the latter shows invariably a larger quantity of intervening cement, and presents a less

variability in its ridge formula, which does not appear to exceed x 6 x in either jaw. The tooth altogether, like the succeeding, is relatively more massive and the enamel thicker, and more wavey in outline than is ever seen in the Mammoth.

The close affinities between the skull of the Asiatic Elephant and the Mammoth extends also to the molars. In the latter this is apparent as regards the ridge formula, which is precisely the same in both, as also the attenuation of the plates to some extent.[1] When the molar crown of *E. antiquus* and *E. meridionalis* were confounded with that of the Mammoth, one was apt, from fragmentary specimens of the former resembling *E. Asiaticus*, to correlate the two more closely in their dentition, and even weather-stained molars of the latter were not unfrequently mistaken for Mammoths' teeth.[2]

I am not aware that the teeth, or any portion of the skeleton of the youthful stages of growth above described, have been found in either Scotland or Ireland. The penultimate milk tooth is common in collections from the brick-earths of Ilford and neighbouring localities, also in gravels and river deposits about Oxford. It has been found, as just indicated, in the caverns of Devonshire and Mendip Hills, Somersetshire, where, doubtless, as in similar situations, it represents the *rejectmenta* of numerous victims of the great Carnivores. As to the specimens from the Norfolk Coast, the same uncertainty as to their stratigraphical relations obtains as with other portions of the skeleton of the Mammoth asserted to have been found in the Forest Bed.

The Fourth or Ultimate Milk Molar.

The last of the milk series is plentiful in collections. It invariably marks a rapid increase in the growth of an Elephant, as revealed by the much larger sizes of the incisors and molars in comparison with penultimate milk teeth.

[1] Falconer, in summing up the data regarding the ridge formula of the milk series in comparison with the same teeth in the Indian Elephant, observes that the former is "liable to the same variation as regards the *ante*-penultimate (the italics are mine) upper and lower as is met with in that species, namely, the ridges varying from seven to eight," 'Pal. Mem.,' vol. ii, p. 163; see also 'Quart. Journ. Geol. Soc.,' vol. xxi, p. 327. Clearly this "slip of the pen" refers to the third or penultimate, and not the second or ante-penultimate. The mistake is apt, however, to mislead, and seems to me worth indicating.

[2] Among the very varied and very imperfectly named and classified proboscidean remains of the 'Fauna Antiqua Sivalensis' there are several figures referred by Dr. Falconer to *E. planifrons* and *E. Hysudricus*, which might be most advantageously compared with the remains of the European and living Elephants, but as this would imply a detailed acquaintance with all the vast and heterogenous materials collected by Falconer, Cautly, and others, in the British Museum and elsewhere, an undertaking the first, with his profound knowledge of the subject, seems to have shrank from entering upon. I can, therefore, only indicate here a few of the more suggestive teeth and bones with which the same parts of the Mammoth might be compared; for example, the first and second milk molars of *E. planifrons*, erroneously named *E. Hysudricus* (see 'Pal. Mem.,' vol. i, p. 442, footnote; pl. xiv, fig. 10; and pl. vii, figs. 5 and 6), representing the same dental conditions in *E. Hysudricus*.

Upper molars.—A suggestive example is furnished by the incisive alveolus with the two tusks *in sitû* (woodcut, fig. 1, p. 130), and a detached upper and two lower molars of the same individual from the brick-earths of Ilford in the Museum of Practical Geology. Unfortunately the remainder of the skull is wanting, but the gradual divergence of the incisors from the roots to the points of exit is well shown. The intermediate distance between them at the former is $5\frac{1}{2}$ inches, and at the latter 9 inches; the maximum breadth of the alveolus at its free border being 12 inches.

The tusks diverge and protrude a distance of 16 inches beyond the incisive sheaths, and are blunt-pointed, and curve outwards, with a maximum girth of $7\frac{1}{2}$ inches. These defensors far exceed the dimensions of the tusks of either of the recent species at a corresponding age.

The upper molar in the above is just commencing wear, the last two or three ridges not having been invaded. It shows, as well as the lower teeth, the *thick* enamel of the Ilford molar as compared with teeth from Crayford on the opposite side of the Thames. The ridge formula in the upper tooth is *x* 11 *x* in $4\frac{3}{4} \times 2$ inches, whilst the lower hold each *x* 12 *x* in $5\frac{1}{2} \times 2$ inches.

A palate specimen, No. 19, Brady Collection, B. M., and also from Ilford, contains two molars *in sitû*, showing the same characters and dimensions of the upper tooth just referred to; it is a good illustration of the palatal region of this stage of growth or that of adolescence.

A very characteristic specimen of a well-worn upper molar is shown by No. 5489 (Pl. XII, fig. 2), from "the Sloping Chamber, Kent's Cavern," where it was found in "the fourth-foot level of cave-earth, 24th June, 1871, along with a tooth of Hyæna." This tooth is a further illustration of the *thin*-plated or typical crowns of the Mammoth as distinguishable from the *thicker* enamel of such as the molars found at Ilford. The fore part of the crown in fig. 2 has been ground away, leaving ten disks in wear, and traces of an original ridge formula of *x* 10—11 *x*. It is entire as to length and breadth, and has a fragment of the alveolus attached. The two other crowns, from Kent's Cavern, of upper molars, Nos. $\frac{1}{3}\frac{2}{4}\frac{-}{3}\frac{-}{8}$ and 2902, fully support the characters of the above.

I have been thus desirous to refer at some length to the deciduous molars from Kent's Cavern, not only on account of the typical character of the worn crown, but as exponents of the exhaustive method pursued by Mr. Pengelly in chronicling the records of the famous Cavern of Torquay—a mode of procedure deserving of imitation in the working of future bone caves.

Another palate specimen in the British Museum is from Hutton Cave, in the Mendip Hills. The right tooth is in place, but instead of *x* 12 *x* shows a ridge formula of *x* 11 *x* in $4\frac{1}{2} \times 1\frac{1}{4}$ inches.

The enamel and dentine are *thick*, so that eight ridges are contained in $3\frac{1}{4}$ inches. The molars of the Elephant found in 1715 at Belturbet, in Cavan, and figured by

Molyneux in Vol. xxix of the 'Philosophical Transactions' (fig. 2 of Plate to No. 346), represented an upper ultimate milk tooth holding x 11 x in $5\frac{3}{4} \times 1\frac{3}{4}$. In the late acquisition made by the authorities of the British Museum of the collection of Pleistocene Mammals collected by Mr. Owles from dredgings on the Dogger Bank, off the Yorkshire Coast,[1] is a palate containing two ultimate milk molars, each of which has a ridge formula of x 12 x in $5{\cdot}2 \times 2{\cdot}4$ inches. The crowns converge in front where the intervening space is 1·9 inches. At the middle it is 2·9 inches, and posteriorly at the talons 3·6 inches. The machærides of the enamel are slightly crimped near the middle of the disk.

Through the kindness of my friend Professor McKenny Hughes, I have been enabled to examine the fine collection of Proboscidean remains contained in the Woodwardian Museum, Cambridge. Among the treasures from British strata is a series of Mammoth molars from Kirby, Melton Mowbray, in Leicestershire, amounting to some twenty specimens, which were presented by the late Professor Phillips. The remarkable feature relating to these teeth is, as before stated, their small size, as compared with the ordinary grinders of the species, and their consequent resemblance in that respect to the Ilford molars. A third upper milk molar (No 42) holds x 12 x in $4\frac{1}{2} \times 1\frac{3}{4}$, and eight ridges in a space of $2\frac{1}{4}$ inches. This tooth, when compared with No. 39 of the above collection, is relatively smaller, and would indicate that the latter belonged to the next in succession, with which I have no hesitation in placing it.

The crown elements here indicate a *thin* plate, but not so pronounced as in many other teeth from British localities.

Another (No. 22) in the same collection, from gravel at Barton, near Cambridge, holds x 12 x in $4 \times 2\frac{1}{2}$. Here the crown is unusually broad, and the tooth short and stumpy. The plates are *thin*, and eight ridges are contained in $2\frac{1}{2}$ inches.

The Brady Collection (No. 20, B. M.) contains two upper ultimate milk molars, with as low a ridge formula as x 10 x in $5 \times 2{\cdot}4$. Each contains eight ridges in $2\frac{3}{4}$ inches, and I have seen another molar of the upper jaw, also from Ilford, with x 10 x in only $3{\cdot}8 \times 1{\cdot}6$ inches. There were eight ridges to $2\frac{1}{2}$ inches. These small teeth and low formulæ in Mammoth molars from Ilford will be seen to agree with the disposition to similar characters in their true molars, especially the last of the series, and, as has just been stated, in connection with the penultimate milk molar.

The lowest ridge formula I have seen in this member of the milk series, repeating in fact the maximum number in the penultimate, is displayed by a specimen in the British Museum from Epplesheim, in Germany. It holds x 9 x in $4\frac{1}{2} \times 1\frac{1}{2}$ inches, and eight ridges in a space of 3 inches. The enamel is *thin*, with rather an unusual excess of the other dental elements. It is interesting to compare the above with the penultimate milk tooth from Ilford, described at p. 90, as it shows Falconer's rule, that "the members are

[1] Mr. Davies, F.G.S., has lately contributed a paper to the Geological Magazine, vol. v, 1878, on the Animal Remains from this situation.

never transposed or reversed,"[1] does not invariably hold good by any means. To suppose that the specimen, p. 90, is also a last milk molar would make the owner a dwarf.

Of fourteen entire last *upper* milk molars, nearly all of which were from British strata, I found *one* with a ridge formula of *x* 9 *x*, *two* holding *x* 10 *x*, *six* with *x* 11 *x*, and *six* with *x* 12 *x*. It would seem, therefore, that the plates vary from 11 to 12 in upper-jaw molars.

Lower molars.—Mandibular last milk molars are equally plentiful, and they are oftener seen *in situ* than the opposing tooth. Great variation in size obtains as usual in jaws of the same age, at all events containing teeth similarly worn, and is, no doubt, a consequence of sex, individual peculiarities, and, as before stated, perhaps local varieties.

Several molars showing various stages in the detrition of this member of the milk dentition from Walton-on-the-Naze, Essex, are contained in the Woodwardian Collection. Among them is a left ramus of a mandible (No. 26), with the third milk tooth in full wear and the fourth appearing above the alveolus, the heel of the former being in a line with the anterior border of the coronoid. The tooth holds *x* 10 *x* in $4 \times 1\frac{3}{4}$ inches. The height of the jaw in front of the milk molar is 4·5 inches, and maximum thickness of the ramus is 3·6 inches. There is no internal foramen in the spout, which is an abnormality in the Mammoth. This ordinarily would be considered a small last milk molar, and is out of proportion to ultimate true molars from the same locality, to be described in the sequel.

A mandible in the Museum of Practical Geology, Jermyn Street, from the brick-earths of Otterham, shows the crowns of two last milk molars with a morsel of the penultimate milk tooth in front of them, and the loose collines of the first true molar in their capsules behind.[2] The stage of growth is that, when the penultimate milk tooth is on the point of disappearing and the last is just coming into use, there being only six of its disks invaded: there is a loss of the condyles and the coronoid, and the left ramus is broken across through the middle of its diasteme. Each milk molar holds *x* 10 *x* in $4\frac{1}{2} \times 1\frac{1}{4}$ inches, the enamel of which is *thin*. The height in front of the fragment of the second tooth is 4·2 inches, and the maximum thickness of the jaw at the base of the coronoid is $3\frac{1}{4}$ inches.

The diasteme is nearly vertical, with a large nutrient foramen at the anterior root of the second milk molar, besides two smaller openings within half an inch of the free margin, and one within the spout.

Another portion of a lower jaw in the same Museum, and from Crayford, in the Thames Valley east of London, presents precisely the same dental conditions as the last, only the ultimate milk molars hold *x* 11 *x* in $4{\cdot}4 \times 1\frac{1}{4}$ inches, the height in front of the penultimate milk is $4\frac{3}{4}$ inches, and the thickness at the base of the coronoid is 3 inches, and there are two external and one internal mental foramina on either side.

[1] Op. cit., vol. ii, p. 10.

[2] The mandible, fig. 86 of the 'British Fossil Mammals, seems to represent this stage of growth.

Three fragments of mandibles from Ilford in the Brady Collection exhibit teeth holding eleven to twelve plates besides talons. One, No. 41, Pl. VIII, fig. 1, is more entire than the others, and has the last milk molar in full wear; and although the first true molar is wanting, no doubt a few of its more anterior ridges had also been invaded.[1] The height of this jaw at the commencement of the diasteme is 4·3 inches, and the maximum thickness of the ramus is 2·5 inches. The diasteme is nearly vertical, and measures $3\frac{1}{2}$ inches from the summit to the floor of the gutter, which has the usual open contour of the Mammoth. It is 4 inches in the antero-posterior diameter. The chin, as usual, is rounded, and the mental foramina amount to two outer and one inner in either ramus. Although the rostrum is lost, like the others, it was evidently small.

The occasional crimping of the machærides of the enamel of the disk is well shown in a much worn lower last milk tooth in the ramus No. 39 of the same collection. This jaw has three outer and one inner mentary openings.

There is a cast of a mandible presented by M. Lartet to the British Museum from Lyons. It shows a last milk tooth holding *x* 12 *x* in $3\frac{3}{4}$ inches. The maximum thickness of the ramus at the base of the coronoid is $3\frac{1}{2}$ inches. The latter is quite erect, but the diasteme is not so perpendicular as in the foregoing. Here there are three mentary foramina on one side and only two on the other.

One of a pair of very typical lower last milk molars, No. 39,041, B. M., from a "Raised Beach" at Bracklesham Bay, is shown, crown and profile, in Plate XI, figs. 1 and 1 *a*. It holds *x* 12 *x*. The enamel is very *thin*, and almost cordate, without the faintest indication of crimping. The crown is quite concave with an anterior curved fang and coalescence of the posterior into a shell, showing that the tooth is not half worn down, and in just that state of detrition which best displays the specific characters of a molar.

No. 16 of the Woodwardian Museum, Cambridge, is a fragment of mandible containing a milk molar from gravel at Chesterton, in the neighbourhood. Here the plates are *thick*, but the grossness arises from an increase of all the elements, more especially the cement and dentine. It holds *x* 12 *x* in $4\frac{1}{2} \times 1\frac{1}{4}$, and 8 ridges in 4·1 inches.

The lower molar, No. 21,315, B. M., from Ilford, and cited by Falconer as a good illustration of the last milk tooth,[2] shows a remarkably narrow crown for that of the Mammoth, but on close inspection of the specimen I find the seven posterior ridges do not belong to the same tooth, and have been cemented to the anterior portion, from which it is clear that the specimen was made up, probably by the late Mr. Ball, who seems to have displayed much ingenuity in patching up broken fossils.

The same average of plates appears to obtain in ultimate lower milk molars as in the upper jaw; possibly an occasional extra ridge may occur in the former.

[1] Pl. ii, fig. 5, of the 'Ossemens Fossiles,' exhibits, perhaps, this stage and state of wear, or nearly so; also De Blainville, pl. x, fig. 3.

[2] 'Pal. Mem.,' vol. ii, p. 162.

The dimension of this tooth varies considerably. In upper molars the antero-posterior measurement is as low as $3\frac{1}{2}$ inches and the maximum $5\frac{1}{2}$ inches, whilst the breadth varies from 1·4 to 2·5 inches.

The lower molar does not appear to exceed the maximum length of the upper, but I have not seen one of the former so low as 3·9 inches in length. Its width is seemingly the same as in the upper. Sometimes molars of this, as in succeeding teeth, show, especially in the mandible, a tendency to arcuation, which, however, as a rule, is not general in the Mammoth.

Affinities.—The ridge formula of this member of the series in *E. primigenius* and *E. Asiaticus* are precisely alike, ranging from nine to twelve plates besides talons. In *E. antiquus* and *E. Namadicus* the numbers extend from nine to eleven plates, whilst in *E. meridionalis* it seldom exceeds eight plates; the same, seemingly, and even a lower number, obtaining in *E. Africanus*, *E. Hysudricus* (?), and *E. bombifrons*.

The only species with which the ultimate milk molar of the Mammoth is likely to be confounded is that of the *E. antiquus*. Ordinarily, the higher expression of the ridge formula and disks will distinguish the former when the crown is well worn; but sometimes, should the wearing down be not pronounced and the number of plates come within the range of that of the Mammoth, the diagnosis might be uncertain. As to the differentiations from the last milk molars of other species, I need not repeat what are detailed at length in my Monograph on *E. antiquus*, p. 20.

Like its predecessor, the last of the milk molars is plentiful in collections from the brickfields east of London, and, whether through accident, disease, or attacks of enemies, the Mammoth did not attain to old age without running many risks, and this is further shown by the undiminished numbers of last milk teeth from bone caverns throughout England. It has also been recovered from the bed of the German Ocean, and represents the most youthful examples of its owner hitherto recorded from Ireland.

3. TRUE MOLARS.

The Ante-penultimate or First True Molar.

A small first true molar may be easily mistaken for a large ultimate milk molar, and the latter for a small first; indeed, the chances of such deceptions are the lot of the most experienced manipulators of Proboscidean teeth. The only certainty occurs either when the molar is found in the jaw or when the larger size indicates dimensions beyond what usually obtains in last milk teeth.

The rapid growth of the living species of Asia, whose life-history is best known, makes greatest progress between the decadence of the penultimate milk and the commencement

of the detrition of the penultimate true molar,[1] and, judging from the sizes of jaws, molars, and tusks, and as far as is known of the long bones, the same obtained in the Mammoth. The first true molar ushers in the adolescent stage, when the animal is said to attain sexual maturity.

Upper Molars.—The molar, No. 46,211, B. M., from the Dogger Bank, shown Pl. XI, fig. 2, presents the very unusual anomaly of containing only nine plates and two talons, and comparable in that respect with the penultimate and ultimate milk-molars referred to at pp. 90 and 95. The double falcated anterior fang supports the first two ridges, and the posterior talon is intact, so that there can be no question whatever of the ridge formula. The crown is $6 \times 2\frac{3}{4}$ inches, and contains the very unusual proportion of not less than eight ridges in a space of $4\frac{1}{2}$ inches, there being nearly 0·8 inch to each plate. This arises entirely from an excessive quantity of cement, which appears to take up the space occupied in other teeth by plates.

A comparison between this anomalous crown and that of a first true molar of *E. antiquus* (Monograph, Pl. III, fig. 2) shows striking likenesses, only that the latter holds x 10 x in 7 inches, and its crown is not nearly so broad.

Upper-jaw teeth, *in situ*, are not nearly so plentiful as lower. The Brady Collection from Ilford, No. c 1, contains a mutilated palate holding two well-worn crowns, but the right is imperfect, and therefore affords little information of the relative dimensions of the palate region. The remains of large incisive sheaths show that the tusk was fully developed. The left molar appears to me to furnish evidence of a ridge formula of x 12 x in $5{\cdot}5 \times 3$ inches, and to contain eight ridges in $3\frac{1}{2}$ inches.

The Woodwardian Museum possesses a molar from Gristhorpe Bay, Yorkshire. It contains x 12 x in $5 \times 2\frac{1}{2}$, and holds eight ridges in 2·7 inches, and might be fairly placed with the *thin*-plated teeth.

There are two detached upper molars, Nos. 15 and 23, in the same collection from the Cambridge gravels, presenting a ridge formula of x 12 x; the former is $5{\cdot}5 \times 2{\cdot}8$ inches, the latter is $5{\cdot}5 \times 2{\cdot}5$ inches, but whilst the former holds eight ridges in 3 inches, the latter shows the same number in a length of $3\frac{1}{2}$ inches. A molar from a cave in the north of Spain, holding x 12 x in $5 \times 2{\cdot}3$ inches, is recorded by me elsewhere.[2] The enamel is *thick*, like that of Ilford molars, and there is faint crimping of the borders of the ridges.

Another upper tooth from Cambridge, No. 14, with x 12 x in 7×3 inches, holds eight ridges in $3\frac{3}{4}$ inches.

Another from Langford, near Rugby, in the Oxford University Museum, with the same ridge formula in 5×3 inches, has eight in $3\frac{1}{4}$ inches, and shows unusual *thickness* of the enamel or dentine, in other words "thick plates."

A tooth found in fluviatile deposits of the Thames Valley at Battersea, London, holds

[1] This is well seen at present in the young Indian Elephants lately presented to the Zoological Society of London by H.R.H. The Prince of Wales.

[2] 'Journ. Geol. Soc. Lond.,' vol. xxxiii, p. 537.

x 13 x in $6 \times 2{\cdot}7$ inches, and eight ridges in $3\frac{1}{4}$ inches. The enamel in this specimen is conspicuously *thin* as compared with that usually seen in true molars from Ilford in the neighbourhood. This specimen is in the British Museum.

The fluviatile gravels in and around Barnwell, Cambridgeshire, have been prolific in remains of the Mammoth. There is a series in the Woodwardian Museum of associated grinders of this species from one situation, comprising two upper well-worn ultimate milk teeth, and two upper first true molars, evidently of the same individual, besides two lower penultimate true molars, and fragments of other permanent teeth, representing, at least, two individuals.

The upper tooth, No. 57, holds x 13 x in $6\frac{3}{4} \times 2\frac{1}{2}$, and contains eight ridges in $3\frac{1}{2}$ inches. The enamel is *thick*—a character which runs through the set.

The tooth (No. 42) from Kirby, Leicestershire, referred to the last of the milk series (p. 95), is rivalled by another and larger molar in the same collection (No. 39). It holds x 13 x in $4\frac{3}{4} \times 2\frac{1}{2}$, and eight ridges in $2\frac{1}{2}$ inches. According to the ordinary size of the last milk, this specimen would be considered by no means a large one; but it contains a ridge over the usual number in a proportionately small species, and is a quarter of an inch longer than the tooth No. 42. These facts, taken into account in relation to the diminutive ultimate molars from the same locality, described at p. 111, one of which is shown in Plate XIII, figs. 1 and 1 *a*, seem to associate all with a small form or race, or else dwarfed individuals. I have therefore placed the above molar among the first true, rather than the last milk teeth. The characters of the crown constituent are as in the other tooth at p. 95, the plates being rather thin and crowded

A still higher expression of the ridge formula in upper molars of this stage of growth is well shown in a tooth in the University Museum, Oxford, from the Oxford gravel under the city. It holds x 14 x in $5\frac{1}{2} \times 2{\cdot}8$ inches and eight in $2\frac{1}{2}$ inches, showing the differences in dimensions as compared with the number of ridges and the *thinness* of the plates as compared with the ordinary Mammoth's molars met with in the lower parts of the river below London. The latter is well shown in an Ilford molar, in which x 14 x are contained in $6\frac{1}{4} \times 2\frac{1}{4}$ inches and it holds eight in $3\frac{1}{2}$.

A molar (No. 25) found in gravel at Westwick Hall, near Cambridge, and now in the Woodwardian collection, contains x 14 x in $7 \times 2\frac{1}{2}$ inches and eight ridges in $3\frac{3}{4}$. The enamel is rather thick and there is slight crimping of the machærides of the disks.

The highest expression of the ridge formula in a tooth referable to this stage of the dentition is represented by two very entire and beautifully preserved molars (Nos. 11 and 12) in the Woodwardian museum from St. Neot's, Huntingdonshire. Each tooth holds x 15 x in $5\frac{1}{2} \times 2$, and has eight ridges in 2.6 inches. The enamel is *thin*. These teeth were accompanied by a long and slender tusk which measures 52 inches in length.

Lower molars.—The same Museum contains two lower molars from Lexden, near Colchester, Essex (Fisher Collection). Each tooth holds x 13 x in $6 \times 2\frac{1}{2}$ inches, and contains eight ridges in $4\frac{1}{4}$ inches.

The plates are rather *thick*, but mostly with reference to the cement and dentine; indeed, all Lexden specimens I have seen vary considerably in the thickness of their plates.[1]

Foreign specimens.—The Museum of the Royal College of Surgeons of England contains several admirable illustrations of lower as well as upper first true molars, said to have been obtained from Ohio, N. America. They are described with Dr. Falconer's usual fidelity, and need no further reference here, excepting as regards their ridge formulæ, which do not exceed $x\ 12\ x$, and the *very attenuated enamel* pointed out by Owen and Falconer.[2] I have already referred to these teeth in connection with the American distribution of the species.

An upper molar, No. 37,293, B. M., from "gravel pits" near Moscow, holds $x\ 12\ x$ in $5\frac{3}{4} \times 2{\cdot}7$ inches with 8 ridges in a space of $3\frac{1}{2}$ inches. The enamel is crimped somewhat near the middle of the disk and is *thick*.

Several suggestive specimens of this tooth are contained in mandibles.

A lower jaw figured and described by Falconer[3] displays the first true molar fully worn, and the empty socket of a fragment of the last milk in front with the tips of the collines of the penultimate true molar just appearing.

In the Brady Collection a further stage in the detrition of the molar in question is well represented in the mandibles, Nos. 43 *c* and 44 *c*. The former is shown (Plate VIII, fig. 2). A crown very slightly more worn, with the second true molar just above the gum and one of its ridges attrited, is represented by No. 47 and No. 45 of the same collection, where several of the anterior plates of the first molar are worn away and two of the anterior of the second in use, whilst No. 46 shows only half of the ante-penultimate remaining and five plates of the penultimate invaded.

All these mandibles present considerable discrepancies in size, irrespective of the state of wear of the first true molar and its predecessor and successor as they happen to be in use or not, and no doubt refer to sexual and perhaps also individual peculiarities; thus the maximum length, thickness, and divergence of the rami, in the order of advancement of detrition of the crown just given, are as follows:

	Length of mandible.	Thickness of ramus.	Maximum divergence of ramus.
F. A. S., pl. xiii, fig. 2.—B.M.	16·8 inches	4·8 inches	16 inches.
No. 43, Brady Collection	19 ,,	4·3 ,,	16·5 ,,
No. 44 ditto	21 ,,	5 ,,	20·5 ,,
No. 45 ditto	23 ,,	5·5 ,,	22 ,,
No. 46 ditto	22 ,,	5 ,,	19 ,,
No. 47 ditto	20 ,,	4·8 ,,	21·5 ,,

[1] Refer to pp. 80 and 110.

[2] 'Brit. Foss. Mammals,' p. 238; 'Pal. Mem.,' ii, 237, and pp. 164 and 171.

[3] 'Fauna Antiqua Sival.,' pl. 13 A and B, and figs. 2 and 2 *a*, 'Pal. Mem.,' vol. i, p. 439. This specimen from Germany is preserved in the British Museum.

When compared with two jaws of the Asiatic Elephant presenting precisely the same states of wear, the differences in these and other characters already noted become at once apparent. In all of the following jaws the ridge formula of *x* 12 *x* is present. The ante-penultimates show well-worn crowns, with the anterior ridges nearly ground down to the common base. The penultimates are in germ with the tips of their collines appearing. They furnish the following metrical data.

	E. Asiaticus, No. 1445 *a*, Osteological Catalogue, B.M.	*E. Asiaticus*, No. 2674, Cat. Mus. Roy. Coll. Surg. Eng.	*E. primigenius*, No. $\frac{c}{44}$ Brady. Collection, B.M. Ilford.	*E. primigenius*, Eppelsheim, B.M. (F. A. Siv., pl. 13 A, B, fig. 2).
	Inches.	Inches.	Inches.	Inches.
Extreme length of the mandible	22½	25	21	16·8
Greatest thickness in front of ascending ramus	5¾	5½	5	4·8
Height in front of the molar	8	6	6	4·7
Greatest expansion of rami (from their outer borders)	18	15¾	20½	16
Length of the molar	6½	6	5·9	5·4
Width at sixth ridge	2¼	2	2·2	2·2
Space between the molars (in front)	3·3	3½	3·4	2·4
Ditto ditto (behind)	5¼	3	6	4·8
Space occupied by eight plates	4½	4	3¼	
Tip of rostrum to posterior border of the gutter	6½	5½	5½	
Antero-posterior length of symphysis below	3¾	3½	3½	
Width of the gutter at its middle	2	2½	3	

Mandible No. $\frac{c}{48}$ of the Brady Catalogue and Collection just referred to, as figured in Plate VIII, fig. 2, is somewhat remarkable for the number and length of its digitations, showing thirteen disks in wear and only five with their digitations worn out. The molars contain respectively *x* 12 *x* in 5·2 × 2·2 inches.

These jaws are fully described by Davies, and present the best series of mandibles of the adolescent stage of growth in the Mammoth that have come under my notice.

The jaw No. $\frac{c}{45}$ presents the remarkably long rostrum shown in Woodcuts, figs. 11 and 25 (p. 139), fully 4½ inches in length; but it descends, and is therefore not in the way of the pre-maxillaries. The well-worn crowns of the molars in the jaw show considerable crimping of the machærides near the middle of the disk. The condyles are entire in this specimen, the distance between them being 13 inches, and each is 3 inches in the antero-posterior, by 3½ inches in the transverse diameter.

No. $\frac{c}{46}$ (Woodcuts, figs. 12 and 26, p. 139), B. M., presents a similar long beak, grooved and continuous with the spout. The mental foramina are irregular as to position. The crowns of the molars show thicker plates than usual in crowns from Ilford; indeed, in all or nearly all of the first true molars from Ilford examined by me there are about eight plates in a space of 4 inches, and in the mandible, No. 47, already cited, that number is

included in the space of $4\frac{1}{2}$ inches. There is an abnormal character worth noting in the jaw No. $\frac{C}{46}$ (Woodcuts, figs. 12 and 26). The dental canal, which as a rule opens, as has been stated, directly upwards in the Asiatic Elephant and in the Mammoth, faces directly backwards in the above, thereby presenting an exception to a very general rule as far as the Mammoth is concerned; the jaw, moreover, shows an anomaly as regards the corresponding levels of the mentary foramina; the beak is also more horizontal than usual (Woodcut, fig. 26, p. 139).

Although the Ilford mandibles of the Mammoth above described belong to smaller Elephants than equivalent remains from several other parts of England and elsewhere, and in length and thickness of the jaw, height of the horizontal ramus, and length of the molars, are conspicuously smaller than in the two mandibles of the recent species, it will be observed that the rami diverge much more, the gutter is wider, and the distance between the heels of the teeth greater in the Mammoth. With reference to the distinguishing characters of the mental region, horizontal and ascending rami, direction of the diasteme, and other points to be again referred to when describing the mandible, although the distinctions are well marked, I find that, as compared with the same parts in the jaws of all other known species of the genus, the mandible of the Asiatic Elephant is more closely related to the Mammoth than to any of them.

To sum up the materials, it would appear that out of twenty upper and lower anterior ante-penultimate molars one holds a formula of x 9 x, twelve of x 12 x, three of x 13 x, three of x 14 x, and one of x 15 x.

Affinities.—The points of difference between the first true molar of the Mammoth and *E. antiquus* are usually well marked. The enamel, whether thick or thin, is never so much crimped, and the absence of the central angulation and expansion, together with the relative greater width to length, can scarcely fail in experienced hands to distinguish a true molar from that of *E. antiquus* and *E. Namadicus*. As to *E. meridionalis*, its massive size, excessive development of cement, thicker enamel, and low ridge formula, will suffice to establish a diagnosis. The Asiatic Elephant, with its narrower crown and densely crimped enamel, make distinctive characters, which are common also to *E. Armeniacus*, *E. Columbi*,[1] and *E. Hysudricus*,[2] with which it deserves to be compared most carefully.

The Penultimate or Second True Molar.

The penultimate true molar, as with its predecessors, shows a progressive increase in the number of its ridges, from the maximum ridge formula of the ante-penultimate to the minimum number in the ultimate true molar; consequently nearly the same uncertainty

[1] Falconer, 'Pal. Mem.,' vol. ii, p. 220 and 247, pl. x.

[2] 'F. A. Sival.,' pl. vii, figs. 2 and 10. *E. Hysudricus* holds x 12 x in its first true molar.

attaches itself to this tooth, as has been pointed out in connection with its predecessors in the dental series.

Until Falconer's differentiations established a ridge formula of x 16 x for the second true molar of the Mammoth, none of his contemporaries or predecessors had estimated the number very definitely.[1] But the average number assigned by him is subject to numerous exceptions, and is apparently, as far as I have been enabled to observe, too high an expression. Falconer states, "I have seen no authentic specimen of an upper penultimate of the Mammoth presenting more than sixteen or seventeen ridges. That exceptional cases do occur in which as many as eighteen may be seen is not improbable, but, I believe, that as holds in the existing Indian species the prevailing and normal number is sixteen."[2] He also refers to the tooth described by De Blainville,[3] in which fourteen collines exist, and doubts if the molar belongs to the Mammoth. That a penultimate true molar of the Mammoth may contain this ridge formula is proven, it appears to me, by the following instances.

Upper molars.—In the rich collection of molars belonging to the Mammoth lately obtained from the Oxford gravel, and now in the University Museum, is an upper and lower penultimate true molar, each containing x 14 x. The upper is $6{\cdot}7 \times 2{\cdot}8$ inches, and contains eight ridges in $3\frac{1}{4}$. The other will be referred to presently.

Another and smaller upper tooth, holding the same x 14 x ridge formula in 5×3 inches, and eight ridges in $3\frac{1}{2}$, is preserved in the Museum of Practical Geology, Jermyn Street. It is from the lower brick-earths of Crayford on the Thames, and is interesting also on account of the *thin* enamel of the crown, as compared with that of the Ilford specimens, as will be referred to again presently.

The two molars, No. 23,115, evidently of the same individual, from Maidstone, Kent, in the National Collection, show the ridge formula of x 14 x in $7 \times 2\frac{1}{2}$, and eight ridges are contained in 3·9 inches. That these teeth are penultimate true molars is at once apparent from their size and the characteristic declination of the posterior ridges, and the flat pressure mark on the last ridge and fang. The disks present the usual parallel, narrow, and uncrimped characters of the Mammoth. The enamel is *thick*, and the plates much digitated, as often prevails. It is noteworthy that several of the posterior plates present roughenings and irregularities, as if several additional ridges had been suppressed during development, and might, if unsupported by further data, be considered deformed teeth, but the other instances and examples in lower teeth, to be referred to immediately, appear to me sufficient to establish the not uncommon ridge formula of x 14 x in second true molars.

[1] Owen states it "may have from sixteen to twenty-four plates." De Blainville mentions molars with fourteen, eighteen, and nineteen plates or collines. 'Brit. Foss. Mam.,' 'Odontography,' p. 666, and 'Ostéographie des Eléphants,' pp. 195, 357.

[2] Op. cit., vol. ii, p. 168.

[3] 'Ostéog. des Eléphants,' p. 195.

There is an upper molar in the Oxford University Museum from Christian Malford, in Wilts, which was found "in stiff clay." It holds *x* 15 *x* in $6\frac{1}{2} \times 3$ inches, and eight ridges in 3 inches. This tooth is assuredly a second true molar, and the plates are *thick*, whilst the crown is diagnostic of the Mammoth.

A tooth in the Museum of Practical Geology, from Maidstone, has *x* 15 *x* in $7 \times 2\frac{3}{4}$ inches. Its enamel is rather *thick*.

A tooth, No. 46,147 (Pl. IX, figs. 1 and 1 *a*, half natural size), from the Dogger Bank, in Mr. Owles's Collection, B. M., shows *x* 15 *x* in $8 \times 2{\cdot}6$ inches, and eight ridges in 3·2 inches. It displays a very broad heel and posterior talon. The crown is typical of the Mammoth, and is *thin*-plated.

A fine specimen, supposed to be from the Arctic Regions, is in the collection of the British Museum. It holds distinctly *x* 15 *x* in $7\frac{1}{4} \times 3$ inches. The sculpturing of the worn disk is typical of the Mammoth; and the size and contour of the tooth assuredly represent the penultimate.

The upper molar, No. 21,272, B. M., from Epplesheim, shows a ridge formula of *x* 15 *x* in $6\frac{1}{2} \times 2\frac{1}{2}$ inches, and eight in $3\frac{1}{4}$ inches. There is no crimping, and the tooth is very typical, having *thin* enamel.

The addition of another ridge to form the formula *x* 16 *x*, asserted by Falconer as distinctive of the second true molar of the Mammoth,[1] although present in a few lower teeth, has not come under my notice in a perfectly entire upper-jaw specimen. There are a few penultimate upper molars holding sixteen ridges in the British Museum and in other museums, but none are so entire as to show the sixteen plates, with an anterior as well as a posterior talon. I make no doubt, however, that numerous instances could be added to those given by Falconer; and even another ridge is most probably often present, although I have not hitherto seen an upper tooth with such a high ridge formula. Indeed, looking to the data furnished by the specimens of upper molars which have come under my notice, I find out of seven entire and, to all appearances, undoubted instances of this tooth from various British and foreign localities, three exhibited a ridge formula of *x* 14 *x* and four of *x* 15 *x*.

Lower molars.—The lower penultimate true molar fully sustains the variability of the formula represented by its upper tooth.

No. 40,790, B. M., from the Thames Valley "brick-earths" (?), exhibits *x* 14 *x* in $8 \times 2\frac{1}{2}$, and holds eight ridges in $4\frac{1}{2}$ inches. Here the plates are *thick;* there is little cement, but thick enamel, with the crown well arcuated.

The same number of ridges is contained in a tooth from the Oxford gravels in Oxford University Museum. It is $6\frac{1}{2} \times 2\frac{1}{2}$ inches, and holds eight ridges in 3·8 inches.

Two molars, evidently of the same individual, each holding *x* 15 *x* in $8 \times 2{\cdot}8$ inches, and eight ridges in $3\frac{1}{2}$ inches, are preserved in the Museum of Science and Art, Dublin.

[1] Op. cit., vol. ii, p. 166.

They were found in Shandon Cave, along with other remains of the Mammoth, including two upper penultimate molars, possibly of the same individual, but the last-named teeth have been ground down to their common base in front, consequently cannot be placed in their position in the dental series with the same certainty, although I doubt not they were the opposing teeth of the two in question. Judging from the small size of the tusks which accompanied them, the probability is that they belonged to a female. The enamel is *thick*, and the cement is in excess, whilst the crowns of the upper molars are unusually convex, and those of the lower preternaturally concave.

A superb specimen of a lower second true molar, Plate XII, fig. 1, from Crayford, Thames Valley, holds *x* 15 or else 16 *x* in $8\frac{1}{2} \times 3\frac{1}{4}$ inches. The anterior portion of the crown is worn to the common base, so that the number of ridges is not quite clearly defined; however, the tooth is perfect with that exception, and the loss cannot exceed a ridge at the most. It was obtained from the "lower brick-earth," and is in the Museum of Practical Geology, Jermyn Street. Like other molars from the above locality, it presents a *thin* enamel as compared with the *thick* of the Ilford specimens.

Two molars (Nos. 54 and 55) in the Woodwardian Museum, from gravel at Barnwell, near Cambridge, hold *x* 16 in $7 \times 2\frac{1}{2}$ and eight ridges in $3\frac{1}{4}$. Neither is quite entire, but No. 54 does not seem to have lost more than its posterior talon. I have referred before[1] to this tooth as one of a series from the above locality. The specimens indicate rather small individuals, which contrast with the stupendous femur in the Museum of Zoology, Cambridge, from the same locality, the length of this thigh bone being 50 inches.

Two somewhat arcuated molars, each showing *x* 16 *x* in $8\frac{1}{4} \times 2{\cdot}8$ inches, and containing eight ridges in $3\frac{1}{4}$ inches, are present in a mandible lately discovered during the Oxford main drainage works. The specimen is in the University Museum. The mandible, like the teeth, presents all the characters of the Mammoth. The height of the jaw in front of the molars is $6\frac{1}{2}$ inches, and breadth of the spout in front between the erect diastemes is $2\frac{1}{4}$ inches. The posterior portion of the jaw is wanting.

There are several fragments, and nearly entire true molars, from Heddingham, Essex, in the British Museum. Among them is a nearly entire penultimate lower molar, holding *x* 15 in $8\frac{1}{2} \times 2\frac{1}{2}$ and eight in $4\frac{3}{4}$ inches. The remarkable peculiarities of these teeth are that this penultimate and another fragment show unusual *thickness* of enamel and cement, whilst another displays the *very reverse*. In consequence of these discrepancies in teeth from the same locality and evidently similar deposits, it seems to me that all attempts to correlate thick and thin plated varieties of the crowns of molars in connection with localities receives a marked exception in this instance and in other cases, as will be shown in the sequel.

A ridge formula of *x* 17 *x* in $7\frac{1}{4} \times 2{\cdot}7$ inches, and containing eight in 3·3 inches, is well shown in another mandible in the Oxford University Museum, from deposits underlying Oxford.

[1] Page 100.

A crown, No. 614, Museum Royal College of Surgeons of England, supposed to be of Arctic origin, and likely so, as the tooth is withered and dark-coloured like Siberian teeth, holds distinctly *x* 17 *x* in 8×3·8 inches, and eight ridges in 2·8 inches. The enamel is very *thin* and uncrimped.

In the Woodwardian Museum there is a lower molar, No. 300, which holds *x* 18 *x* in $7 \times 2\frac{3}{4}$, and contains eight ridges in 4·2. The locality unfortunately is unknown: that it is a second or penultimate true molar is at once demonstrated by the flattening on the heel, and pressure scar of the ultimate in that situation.

Another in the same collection from St. Neots, Huntingdonshire, has the crown much bent, and holds 18 *x* in $8\frac{1}{2} \times 2\frac{3}{4}$, with the loss of the anterior talon only. Here the narrow crown is like that of the Mammoth, with which, however, it has no other common characters. These two teeth bring the extremes of the second true molar up to the minimum expression in the ultimate, as will appear presently.

Mandibles representing various states of wear of the penultimate molar are not uncommon in collections. They exhibit similar individual discrepancies in relative dimensions as mark the jaws of the preceding member of the dental series, and are suggestive of the characters of the mandible of the Mammoth.

A typical instance is shown in a mandible from Erith, Kent, in the British Museum, where three collines of the last tooth are seen emerging above the gum, but are $1\frac{1}{2}$ inches below the level of the crown, whilst the second true molar, with fourteen plates and a posterior talon, is more than half ground down. Perhaps the anterior talon and first plate are worn out, as the heel of the tooth is $1\frac{1}{2}$ inch in front of the anterior border of the coronoid. The diastema has been restored with plaster, but the height of the jaw in front of the tooth is $5\frac{1}{2}$ inches. The enamel, as in the Crayford molars, is *thin*. The length of the crown is $6\frac{1}{2}$, and breadth 2·9 inches.

The jaw, No. 48 C., Brady Catalogue, is another good illustration. It is broken across behind the penultimate molars, and the preceding teeth have lost a ridge or two, leaving 15 *x* in 7·7×3·3 inches.

Here the enamel is *thick* and crimped, a character oftener seen in Ilford molars than in the majority of teeth from British strata, the abnormal crimping and expansion of the disks of this specimen are, as suggested by Davies, doubtless owing to the obliquity of wear of the crowns.

The rostrum in Woodcuts, figs. 10 and 24 (p. 139), shows a shallow groove down the middle, and the mentary foramina are irregular, there being three on the right and only two on the left.

A mandible, No. 38,567, B.M., with the second true molar much detrited, and the last coming into wear, there being only five of the anterior ridges just invaded, is represented by a specimen "from Peat," in the harbour of Holyhead, got during excavations in connection with its docks.[1] (See Woodcuts, figs. 6 and 20, p. 138). The jaw has lost its

[1] Lyell, 'Principles of Geology,' vol. i, p. 545.

posterior portion behind the third molars, which are also incomplete, there being only eighteen anterior plates remaining. The second is more than two thirds worn, with only nine plates remaining, and its heel is three inches in advance of the anterior border of the coronoid.

The disks are narrow, free from crimping; the enamel is *thin*, with rather an excess of cement.

The diastemes (fig. 20) are erect, and contract the interspace in front (fig. 6), considerably more so than usual, their borders being only two inches apart, and one of the mental foramina passes directly through the jaw into the gutter close to the internal nutritive canal of that channel. The upper and outer opening is just under the fang of the anterior tooth.

In the *thinness* of the enamel, narrow disks, and rather thick intervening cement, the above and some molars said to have been found in the Forest-bed present agreements.

The superb mandible, No. 49,196, dredged off the Dogger Bank, is figured and described by Falconer,[1] who, however, does not appear to have been aware of its origin. It represents the transition stage when the second true molar is two thirds worn and about one third of the ultimate tooth is invaded. The heel of the penultimate is three and a half inches in front of the anterior border.

The above is an interesting specimen in two ways. The *thick* enamel is exceptional in Dogger Bank specimens; secondly, it is rather a famous jaw, having been the one represented on the front covers of the 'London Geological Journal' during its able editorship by Mr. Charlesworth, F.G.S.[2]

About as large a number of lower teeth as is exhibited by the ridge formula of x 14 x, but imperfect specimens, holding as many as sixteen plates and a talon, might be also adduced, but their imperfection makes the diagnosis uncertain. On the whole it seems to me that the majority of penultimate upper molars of the Mammoth will be found to contain a formula of x 15 x.

The entire or nearly perfect skull in the Royal Museum of Brussels from Belgian deposits —a cast of which is in the Museum of the Royal College of Surgeons—displays well-worn crowns of the second true molar. The skull is described at page 128. The mandible holds two teeth, which seem to contain a ridge formula of x 16 x each. The disks of the latter are very narrow, without any crimping of their machærides; but on comparing the crowns of the upper and lower molars, it seems to me, unless the specimens represent a rare abnormality or deformity in the upper molars, that the maxillary teeth, as will be observed in the sequel, do not belong to the jaws, indeed, it may be questionable if the mandible is that of the same individual as the owner of the cranium.[3]

[1] 'F. A. Sival.,' pl. xiii A, fig. 3; 'Pal. Mem.,' vol. i, p. 439.

[2] Davies' supplementary note to "Pleistocene Mammals dredged off the Eastern Coast," 'Geol. Mag.,' vol. v (1878), p. 443.

[3] I may observe that this cranium was presented to the College as being the skull of *E. antiquus*, which it certainly is not.

By compounding the foregoing and other data it seems to me that the ridge-formula of the second true molar of the Mammoth exhibits a formula ranging from *x* 14 *x* to *x* 16 *x* (rarely), and in the lower jaw from *x* 14 *x* to *x* 18 *x*. Moreover, that the most usual formula in upper molars would seem to be *x* 15 *x*, and in lower *x* 16—17 *x*. The ratios in the latter being, out of twelve entire molars, as follows:—Two had a formula of *x* 14 *x*, two of *x* 15 *x*, three of *x* 16 *x*, two of *x* 17 *x*, and two of *x* 18 *x*.

The range in equivalent teeth of *E. Asiaticus* is not, as far as I have been able to make out from many specimens, so great as in the Mammoth, and although as low a figure as fifteen plates, and even seventeen plates, with talons, may occur occasionally, the normal and very steady number of sixteen, besides accessory ridges, seems to prevail in that species.

The *E. Hysudricus*, whose dental characters present several interesting comparisons with both of the preceding, shows in the approximation of its ridge-formula, as well as the disk patterns, certain affinities with them, but more especially with the Asiatic Elephant.[1]

In comparing the tooth of *E. antiquus* with that of the Mammoth, I have stated elsewhere[2] that the ridge-formula of the latter seldom averages less than *x* 16 *x*, being then unaware of the instances I have just pointed out, and resting on the data furnished by Falconer. I believe this number is not nearly so frequent, at all events in teeth from British strata, as the formulæ *x* 14 *x* and *x* 15 *x*, which seem to me about equally common to the second true molar in either jaw. Moreover, it appears to me extremely unlikely that any practised observer would confound entire specimens of the Mammoth's second true molar with that of any of its congeners. Fragmentary specimens will always be puzzling, but a well-worn crown, with its high ridge-formula and characteristic sculpturing of the worn surface, can scarcely be mistaken for that of any species hitherto described.

The Ultimate or Third True Molar.

The ridge-formula of the last of the dental series in the Mammoth ranges from *x* 18 *x* to *x* 27 *x*, and probably individuals may be met with presenting a still higher number of plates.

The characters of the last tooth are too patent to lead to mistakes in practised hands, admitting, as in all cases of other members of the series, it is perfectly entire and the crown sculpturing pronounced.

Upper Molars.—The lowest expression of ridges which has come under my notice is shown in No. 47,122, B. M., in a tooth from "river gravel at Kettering, Northampton." This upper molar holds *x* 18 *x* in $10 \times 4\frac{1}{4}$ inches, and eight ridges are contained in $4\frac{3}{4}$ inches. The plates are *thin* and there is faint crimping of the machærides.

[1] Compare pl. vii, fig. 3, 'F. A. Siwal.,' with fig. 4 of the same plate, erroneously stated as being the tooth of *E. Hysudricus*, whereas it belongs to *E. Asiaticus*, 'Pal. Mem.,' i, p. 428.

[2] 'Monograph,' p. 30.

There is an ultimate upper molar in the Woodwardian Museum, possibly that referred to by Falconer as bearing "all the marks of having come out of the licks of America or a peat-bog in England." If this be the one in question he overlooked the low ridge-formula of *x* 18 *x*, which is contained in 9×3 inches.

Another in the same collection from "Newton, Isle of Wight," holds *x* 18 *x* in 9×3 inches, and contains eight ridges in 4 inches. The enamel is *thin*, but the dentine, and especially the cement, is somewhat in excess.

Mr. Davies appears to have been the first to indicate so low a ridge-formula as *x* 19 *x* in the Mammoth[1], inasmuch as Dr. Falconer had fixed the range between *x* 22 *x* to *x* 26 *x*, the prevailing number being about twenty-four plates.[2]

The remarkable smallness of the teeth in the Ilford collections, as compared with molars from the opposite bank of the Thames and its upper portion, is well seen in this member of the series. That the Mammoth which frequented the valley of the river at and below London during the period of the deposition of the Pleistocene brick-earths and gravels should have differed from others in the immediate neighbourhood is scarcely likely, supposing all were living in the district at the same time; but indeed it would be difficult to prove that they were denizens of the exact localities where their remains are now found.

There are several remarkably small molars described by Davies, in which only nineteen plates and two talons exist. One is No. 3 of the Brady Catalogue, showing *x* 19 *x* in the small antero-posterior measurement of *eight* inches; the maximum breadth of the crown is 3·2 inches

The cranium (Pls. VI and VII, figs 1, 1 *a*) from the same locality represents an aged Mammoth with an ultimate molar, containing the ridge formula of *x* 19 *x*. The posterior portions are partly hidden in the alveoli, but the breadth of the crown is 2·8 inches, and maximum girth of the tusks 24½ inches. The specimen is suggestive, even with reference to the recent species, by showing that, as in them, the largest Elephants do not necessarily present the largest tusks.[3] The dimensions of this skull will be referred to presently.

Several remarkable specimens of true molars were discovered in a peaty deposit at Lexden, near Colchester, and are now preserved in the British Museum.[4] Of these, No. 36,426 is a right and left upper ultimate molar, probably of the same individual. Each holds *x* 19 *x* in 9·4×2·8. The former is shown in Pl. XIV, fig. 2.

In all the teeth from the above situation the enamel is *very thin*, but the cement and dentine are in excess, so that eight ridges are contained in a space of 3½ inches. The disks are more or less crimped, and the specimens are light and present the black

[1] Brady, 'Catalogue,' p. 3.

[2] 'Pal. Mem.,' vol. ii, p. 168.

[3] 'Livingstone's Travels in South Africa,' p. 562; Tennent's 'Ceylon,' vol. iv, p. 291; Baker, 'Nile Tributaries of Abyssinia,' p. 533; 'Albert Nyanza,' vol. i, p. 275.

[4] A full description of this discovery is given by the Rev. O. Fisher, F.G.S., in the 'Quart. Journ. Geol. Soc.,' vol. xix, p. 393.

colour and friable consistence characteristic of remains from peat. They are recorded to have been found in conjunction with remains of *Rhinoceros leptorhinus*. The crown constituents of all these Lexden molars—and they represent, at all events, two individuals —present the same relative proportions as the Mammoths' molars from the Dogger Bank; there are, moreover, a last upper and a fragment of another true molar from the same locality in the Museum of Practical Geology. Both present similar features, and hold eight ridges in $3\frac{1}{2}$ inches.

The British Museum has acquired lately an upper molar from Aylesford in Kent, the ridge-formula of which is x 19 x in $10 \times 2\frac{1}{2}$ inches. It is stated to have been from "gravel."

The molar figured in the 'Fauna Antiqua Sivalensis,' pl. 1, fig. 1, and sawn up the middle, is in the British Museum. It is labelled from Bacton, Norfolk, and appears to me to show a ridge-formula of x 19 x in 11×3 inches. Falconer states that it holds twenty-one plates, with the supposition that it is not quite entire, but I think a careful inspection of the tooth will show that it is entire, and has two accessory ridges or talons. The plates are rather thick, the excess being about equally divided in the three elements. As many as 4 inches are included in an antero-posterior measurement of eight plates.

The progressive increase of plates is well illustrated by numerous British and foreign specimens in various collections.

During the formation of the Stowe Valley Railway, in a cutting near Lamarsh, several molars of the Mammoth were discovered, which are now in the National Collection. Among others is an upper ultimate, containing x 20 x in 9×3 inches, and eight ridges in $3\frac{1}{4}$ inches.

In the Oxford University Museum there is an ultimate molar, containing x 20 x in $10 \times 3\frac{1}{2}$, and eight ridges in $3\frac{1}{2}$ inches. It was obtained from Leighton Buzzard, Bedfordshire.

In the Woodwardian Museum, Cambridge, there is a molar, No. 7, from Crayford, which contains x 20 x in $10\frac{1}{2} \times 3\frac{1}{4}$, and holds eight ridges in 4 inches. The machærides of the disks are slightly crimped in the usual position, viz. along the central portion of the anterior border, and the enamel is *thin*.

In the Phillips collection of teeth, from Kirby, in the Woodwardian Museum, already referred to at p. 95, are several ultimate molars, two of which are among the smallest upper last molars of the Mammoth that I have examined.

No. 35, represented in Pl. XIII, fig. 1 and 1 *a*, has the following inscription indistinctly written on the cement of the left side of the tooth :—"From Kirby Park, 12 feet beneath the surface, 1821. For this and other specimens I am indebted to the liberality of Mr. (name effaced), Melton Mowbry." Indeed, as regards dimensions, this tooth is not larger than the equivalent molar of the largest of the Pigmy Maltese Elephants,

E. Mnaidriensis.[1] There may be a loss of possibly a ridge or two in front, as the crown is detrited to the common base, to about an inch at its anterior extremity, but the scar of the anterior fang, recently broken, is seen on the lower surface, showing that the specimen is almost entire.

It holds *x* 20 *x* in $8\frac{1}{4} \times 2\frac{3}{4}$, and contains eight ridges in 2·8 inches. The enamel is slightly in excess, as compared with Pl. XIV, fig. 1, from Millbank, on the Thames. The cement having been much denuded from the grinding surface and sides, the crimpings of the anterior machærides of the disks come out in bold relief. There are fifteen ridges in wear, and the seven posterior have their digitations still visible. The crown is rather arcuated. Such, like very small grinders, are extremely suggestive, as showing, in comparison with the colossal teeth described at p. 114 and elsewhere, how very much the Mammoth varied in size; as I have stated was the case also with *E. antiquus* and the Maltese dwarf species. Two other ultimate molars from the above locality (Kirby) are of the same small dimensions, to wit, Nos. 30 and 40. The former is of the left side, and is also an upper tooth. It is less perfect than fig. 1, but it holds 20 *x* in only $6\frac{3}{4} \times 2\frac{3}{4}$ inches, and contains eight ridges in $2\frac{1}{2}$ inches. This tooth is clearly much smaller than the foregoing, and from the void in front appears to have held more than one plate; so that, supposing it had contained two or three additional ridges, it would have scarcely been as large as the last molar of the dwarf *Elephas Mnaidriensis*, shown in pl. xii, fig. 1, vol. ix, of the 'Transactions of the Zoological Society of London.' Indeed, it may be well said that "there were dwarf Mammoths as well as dwarf Maltese Elephants." At the same time, that larger individuals sojourned in the same locality with the above is shown by the other molars referred to already, and ultimate molars to be noticed presently.

The same collection contains three molars from Walton-on-the-Naze, Essex. No. 64 *bis* holds *x* 19—20 *x* in $11\frac{1}{2} \times 3$ inches, and is quite a typical crown; the other, No. 104, is much bent and very narrow, like that of *E. antiquus;* it holds *x* 20 *x* in 12×3. The enamel here is *thin* and the cement is much in excess, and the machærides are very little crimped. The crown contains eight ridges in 5 inches.

An upper tooth of large size from Eppelsheim, and holding *x* 20 *x* in $12 \times 3\frac{1}{2}$ inches, is in the National Collection. The plates are not thick for the dimensions of the molar, eight being contained in 4 inches. Another, but fragmentary, specimen of a true molar from the same locality presents *thin* enamel, with little intervening cement, and holds eight ridges in a space of 3 inches.

The addition of an extra ridge, or a formula of *x* 21 *x*, in upper last molars is represented by numerous specimens from British and foreign localities.

[1] "Dentition and Osteology of the Maltese Fossil Elephants," 'Trans. Zool. Soc. Lond.,' vol. ix, p. 36. I apprehend that last true molars of the largest of the Maltese Elephants attained a length of eight inches. Dr. Falconer refers to "a dwarf-sized molar of *E. primigenius* in the possession of Mr. Prestwich from a railway-cutting at Bedford, 'Pal. Mem,' vol. ii, p. 169.

A very large molar, dredged up from the bed of the German Ocean off Walton, on the Essex coast, and now in the British Museum, holds *x* 21 *x* in $11\frac{1}{2} \times 3\frac{1}{2}$ inches. There is faint crimping of the crown-disk, but none of the constituents are in excess.

Another in the same collection, with thick edges of cement and *thin* enamel, from a railway-cutting near Ipswich, Suffolk, contains *x* 21 *x* in $9\frac{3}{4} \times 3\frac{1}{2}$ inches, and eight plates in a space of 4·2 inches. A fragment of a third milk-molar was also discovered in the same situation. It holds eight ridges in 3 inches, and indicates a similar character.

No. 37,248, B. M., a superb and typical crown (Pl. XIV, fig. 1), dredged up from the Thames near Millbank, holds *x* 21 *x* in $9 \times 3{\cdot}2$ inches, and eight ridges in 3·2 inches. The enamel is *thin*, but there is no excess of cement nor of dentine, nor any indication of crimping.

A tooth from Broughton Fissure, near Maidstone, holding *x* 21 *x* in 9 inches, and eight plates in $3\frac{1}{2}$ inches, is preserved in the University Museum, Oxford.

In the collection in the British Museum from the Dogger Bank, already referred to at p. 73, are numerous, entire, ultimate molars, with ridge-formulæ varying between twenty-one to twenty-six plates, besides talons. They show the great discrepancies in dimensions between molars with the same ridge-formula. One, a superb specimen, carries *x* 21 *x* in $12 \times 3\frac{1}{2}$ inches, and eight ridges in 3·2 inches; whilst another holds *x* 21 *x* in $8{\cdot}6 \times 3$, and eight ridges in 3 inches.

In the Cotton Collection of the Museum of Practical Geology, there is an Ilford ultimate upper molar holding *x* 21 *x* in $8\frac{3}{4} \times 3$ inches, and eight ridges in a space of $3\frac{1}{2}$ inches.

In Dr. Bree's collection, dredged on the East Coast and English Channel, I examined a large last molar holding either twenty-two or twenty-three plates, besides talons, in $10 \times 3{\cdot}2$ inches.

In the collection of dwarf Elephants' teeth from Kirby, in the Cambridge Museum, is the small, imperfect, upper molar (No. 29), holding 21 *x* in $9 \times 2\frac{3}{4}$ inches, and eight in 3 inches. It contrasts with Nos. 30 and 35 already noticed, in not only holding a larger formula, which possibly exceeded the above, but it is also a longer tooth. The plates are *thin*, but the cement is rather in excess; the characters, however, are the same as the other dwarfed molars from the above-named locality.

There are several well authenticated cases of molars holding *x* 22 *x*.

A tooth from a cavern near Wells, in Somersetshire, in the British Museum shows a ridge-formula of *x* 22 *x* in 9×3, and contains eight ridges in a space of 3 inches. It is decidedly *thin*-plated.

A molar recovered from the Oxford gravels during the main drainage operations of 1877, and now in the University Museum, contains *x* 22 *x* in 10×3 inches, and contains eight plates in 3 inches.

There is a tooth, supposed to have been dredged in the Medway, in the British Museum with *very thin* enamel, sparse dentine, and rather an excess of cement. It holds *x* 22 *x* in $10 \times 3\frac{1}{4}$ inches, and contains eight plates in $2\frac{3}{4}$ inches.

The following are the only two instances of a last upper molar holding *x* 23 *x* that have come under my notice.

A last true molar and an enormous spirally curved tusk were dug up within ten miles of SPALDING, in Lincolnshire, and are now in the National Collection. The former, No. 39,695, Plate IX, fig. 2 (half natural size), is truly a superb specimen, and contains a ridge-formula of *x* 23 *x* in $13\frac{1}{2} \times 3$ inches. The plates are rather thick, but not from any marked excess of any of the elements in particular. It contains eight plates in $4\frac{3}{4}$ inches. The tusk has been already referred to at page 82.

A DOGGER-BANK specimen holds *x* 23 *x* in $10\frac{1}{2} \times 3\frac{1}{2}$, and eight plates in 3·2 inches. Like all the ultimate molars from this shoal in Mr. Owles's collection, B. M., the enamel is *thin*. The abnormality in the configuration of the disks whereby they are united near their middle by reflections of the enamel as shown on the crown, fig. 94 of the British Fossil Mammals, is further represented on that of an enormous last upper molar, No. D, 11, 33 *a*, of the Woodwardian Museum. Unfortunately the locality of this specimen is unknown. The above irregularity is confined also to the anterior disks, which are more or less detrited, to near the common base, and to the extent that only half a disk is preserved on one side, showing that the plates were incomplete near the enamel reflections as well as united for some distance along the middle of the plate. The character is unimportant as a distinction and deserves little attention, but for the circumstance that the somewhat similar condition was advanced by Parkinson as a specific character, apart from that of the usual crown of the Mammoth as then known to palæontologists.[1]

The tooth in question holds *x* 23 *x* in $12 \times 3\frac{1}{4}$ inches and contains eight ridges in $4\frac{1}{2}$ inches.

The ridge-formula of *x* 24 *x* is common in upper molars.

A molar from the DOGGER BANK showing the attenuated enamel, holds a ridge formula of *x* 24 *x* in $11\frac{1}{2} \times 4$, or eight ridges in 3·7 inches, without a trace of crimping on the enamel of the disks.

Another dredged specimen from BRIGHTLINGSEA, Essex coast, in Dr. Bree's collection, has *x* 24 *x* in 9 inches. Like the Dogger-Bank teeth it is remarkable for its *thin* enamel.

There is a very typical specimen of an ultimate upper molar from OHIO among the collection in the Museum of the Royal College of Surgeons, and purchased on the occasion referred to at page 75. It is numbered 615 of the Catalogue and is described by Falconer.[2] Here, there are clear indications of twenty-four ridges, and the tooth is seemingly entire. The maximum antero-posterior measurement of the crown is $12\frac{1}{4}$ and the greatest width $3\frac{3}{4}$ inches. It holds eight ridges in $4\frac{1}{2}$ inches. Cement here is in excess, but the enamel and dentine are sparse as usual in the Ohio teeth.

The *thin-plated crown* appears to characterise also the teeth of Mammoths from CENTRAL FRANCE, as is well shown by M. Logard in the plates of the 'Archives du Mus.

[1] 'Organic Remains,' pl. xx, figs. 5 and 7, reproduced in British Fossil Mammals, as above stated.

[2] 'Pal. Mem.,' ii, p. 169.

d'Hist. Naturelle de Lyon.' Teeth holding apparently $x\,24\,x$ in about $10\frac{1}{2}\times3\frac{1}{2}$ inches are represented in vol. i, plate xi, figs. 1 to 5. The ridge-formula in one specimen, apparently not entire, amounts to twenty-nine plates (see plate xiii, fig. 1). Here the ridges are crowded together and the crowns have all the appearance of Arctic specimens.

A mandible, with the two last molars, in the British Museum, from Bergstrasse, near Heidelberg, has the hinder parts of the teeth hidden, so that the ridge-formula cannot be ascertained with certainty. There are twenty-one plates besides the anterior talons exposed in a space of 9×3 inches. Here the enamel and the other constituents are in moderate quantities, showing a typical crown.

A dark-coloured specimen, said to have been from the Thames Valley, has *thin* plates. The anterior ridge is broken off, leaving $24\,x$ in 9 inches. It contains eight in $2\frac{3}{4}$ inches. This tooth, No. 612 of the Catalogue of the Museum of the Royal College of Surgeons, like 600 of the same collection, being imperfect, is not reliable as regards the formula. The latter is the very characteristic ultimate tooth figured by Parkinson and Owen, and referred by the latter to be a second true molar.[1] It is from Welsbourne, in Warwickshire, and is remarkable for the *thinness* of its enamel, with faint crimping of the machærides of the worn disk, which are well shown in Professor Owen's figure. Only twenty-one or twenty-two plates besides the posterior talon remain, the tooth being much worn; its contour, however, and the unusual ridge-formula for a second true molar, place it unquestionably, as indicated by Falconer, among the ultimate upper true molars of the Mammoth.[2]

There is a huge upper molar, No. 50, in the Woodwardian Museum, holding twenty-four to twenty-five plates besides talons in 12×4 inches. The crown is much arcuated. The locality is unknown, but it is possibly of British origin.

A superb specimen in the Dogger-Bank Collection, British Museum, holds $x\,26\,x$ in 13×5 inches, and contains eight ridges in 4 inches. The inordinate width in this specimen arises from the obliquity of the plane of detrition, which is at an angle of 45°. This condition is not unfrequent in domesticated Elephants fed on dry food, but is rarely seen among wild animals, at all events to the extent shown in the above specimen.

There is in the Beechey Collection from Eschscholtz Bay, in the British Museum, a palate specimen holding a fragment of the penultimate and entire last true molars on either side. The latter contain $x\,26\,x$ in 9×3 inches, and hold eight plates in $2\frac{1}{2}$ inches. Here, as usual, the enamel is *very thin*, and the ridges are packed closely with little intervening cement.

The only instance of an ultimate molar containing $x\,27\,x$ that has come under my notice is represented by a specimen from the "bed of the Cherwell," in the Museum of Oxford University. The tooth is $10\frac{1}{2}\times3$ inches, and contains eight ridges in a space of $3\frac{1}{2}$ inches. The enamel is *thin*, and the disk free from crimping.

[1] "Organic Remains;" 'Brit. Fossil Mammals,' p. 238, figs. 91 and 92.

[2] 'Pal. Mem.,' vol. ii, p. 168.

Several typical *thin*-plated crowns of Mammoth molars, including the last of the series, with from twenty-five to twenty-six plates, are well shown in pls. xi, xii, xvi, and xvii of the 'Archives du Museum d'Histoire Naturelle de Lyon,' by Dr. Lortet and M. Chantre. The specimens were obtained from the valley gravels of the Soane and Loire.[1]

Lower Molars.—I have not seen a lower last molar with so low a ridge-formula as $x\,18\,x$, but doubtless examples might be adduced.

A tooth in the British Museum, from Ilford brickfields, holds $x\,19\,x$ in $9\frac{1}{4}\times2\frac{3}{4}$. The crown shows slight crimping of the enamel, which is *thin*.

A dredged specimen in the collection of Dr. Bree, from the North Sea, holds $x\,19\,x$ in 11 inches. The plates are *very thick*.

No. 127 of the Woodwardian Museum (locality unknown) is possibly the tooth referred to by Falconer,[2] and if so it is surprising that he overlooked the formula, seeing that it clearly holds $x\,19\,x$, being at least three ridges below what he believed obtained in the ultimate molar of the Mammoth. It is $10\frac{1}{2}\times3\frac{1}{4}$, and contains eight ridges in 5 inches, all the elements being in excess.

The formula of $x\,20\,x$ is exhibited in the following:

A mandible, No. 624 A in the Museum of the Royal College of Surgeons of England, from the brick-earths (?) of Grantham, near Crayford, below London, is nearly entire, and besides the ultimate there had been a fragment of the second molar also in use, but it is lost. The former holds $x\,20\,x$ in $12\times2\frac{3}{4}$ inches. The jaw is characteristic of the species, with a high diasteme. The height at the summit of the latter is $7\frac{1}{2}$ inches, and the width of the gutter in front is $2\frac{3}{4}$ inches. The mental foramina maintain their general positions, being near the margin with the larger one, close to the anterior fang of the second tooth.

A mandible with the ultimate molars in place from Erith, Kent, is in the British Museum. Each tooth holds $x\,20\,x$ in $9\frac{1}{2}\times3$ inches. The enamel is *thick*.

No. 582, Mus. Roy. College of Surgeons, is a right ramus with a third molar and fragment of a second in front. The locality is unknown, and the tooth represents a cluster of digitations on the posterior ridge, as in a major degree marks occasional deformities, where the ultimate portion is often doubled up upon the side of the crown. The tooth is much arcuated and thick-plated, and shows a formula of $x\,20\,x$ in $12\times2\frac{1}{2}$ inches, with eight ridges in as much as $4\frac{1}{4}$ inches.

I am indebted to my friend Mr. Davies, F.G.S., for drawing my attention to a very interesting collection of Pleistocene remains in the British Museum, from Porcupine River, on the eastern frontier of Alaska. The collection comprehends two molars and an astragal of the Mammoth, besides remains of the bison, musk-ox, and horse, all of

[1] These authors also figure pls. xix and xx, large massive crowns, which they refer to *E. meridionalis*, from Central and Southern France. These teeth, however, appear to me to belong to *E. antiquus*, and represent the broad and thick-plated crowns described in my 'Monograph,' p. 31.

[2] 'Pal. Mem.,' vol. ii, 174.

which are said to have been discovered in the same deposits by the Rev. R. Macdonald. An entire lower last molar of the left ramus, No. 44,060, holds *x* 20 *x* in $9 \times 3\frac{1}{4}$, and eight ridges in a space of 5 inches. The tooth, as usual in Arctic specimens, has very *thin* enamel, but the cement is in great excess. There is very faint crimping of the thread-like machærides of the former. A fragment of a nearly worn-out crown of a true molar of another individual shows a similar condition of its constituents, whilst the astragal has the projecting posterior and inner angle of the species, and represents a rather small individual. Some of the bones appear to have been gnawed. Mr. Davies had carefully compared the remains of the Bison with the European fossil species, and was unable to make out differences. Similar remains of the latter species are contained in Kellet's collections, in the British Museum, from Kotzebue Sound, and also from Eschscholtz Bay, where Mammoth remains are plentiful.

The presence of *x* 21 *x* in lower ultimate molars is demonstrated by a rolled specimen from Siberia, in the British Museum. It is 11×2 inches in width and is somewhat arcuated. The enamel is *thin*, with slight crimping and rather an excess of cement, eight ridges being contained in $3\frac{1}{4}$ inches. This tooth, although much attrited by rolling possibly in the bed of some mountain torrent, is altogether remarkably narrow for that of a Mammoth.

Dr. Bree's collection contains a dredged specimen, from the East Coast, of an ultimate molar, which holds *x* 22 *x* in $9\frac{1}{2} \times 2\frac{1}{2}$ inches.

No. 40,699, B. M., a crown view of which is shown in Plate XIV, fig. 3, is one of the "waifs and strays" either cast ashore by the waves or fished up by the troll net. It is remarkable for its rather thick enamel, and the plates are much digitated, and the crown considerably arcuated. It holds *x* 22 *x* in $11\frac{1}{2} \times 2{\cdot}8$ inches, and contains eight ridges in $4\frac{1}{4}$ inches. It is recorded in the Catalogue as having been "dredged off Cromer Forest bed."

A tooth from the Dogger Bank holds *x* 22 *x* in $8\frac{1}{2} \times 2{\cdot}6$ inches and contains eight in 3·1 inches. It is remarkable for its small size, and is therefore exceptional as compared with the other ultimate molars from the above-mentioned shoal; even a molar which has evidently lost only its anterior talon holds 22 *x* in $11\frac{1}{4} \times 3\frac{1}{2}$ inches, and contains eight in 3·6 inches. In both the enamel is *thin*.

The Dogger Bank Collection furnishes two specimens of lower molars with a ridge formula of *x* 23 *x* each. One is 13×3 inches and contains eight in 4·4 inches. The plates are rather thick for the size of the tooth, which is $4\frac{1}{2}$ inches longer than the first mentioned. There is, as usual in Dogger-Bank teeth, no crimping of the machærides. The crown is arcuated. The other tooth is $11\frac{3}{4} \times 3$ inches and contains 8 ridges in 3·9 inches. Here the enamel is *thin*, as usual in its companion molars from the above situation. The crown is much arcuated.

In the collection of Dr. Bree, I noticed a molar holding *x* 23 *x*, recorded to have been dredged off Dunkirk. It was 9 inches in length and "*thin*-plated."

The formula of x 24 x in lower last molars is well seen in a superb specimen in the Museum of Zoology, Cambridge University, in which the above is contained in a space of 12×3 inches, and eight ridges are held in a space of $4\frac{1}{4}$ inches. The crown is considerably arcuated, and the specimen shows every indication of having been dredged.

Broken molars.—The largest molar of the Mammoth I have seen from British soil is a fragment of an upper tooth, No. 33,328, B.M., in the Layton Collection, which was made on the Norfolk Coast. This molar when entire must have been of gigantic proportions. There are sixteen plates in $9\frac{3}{4} \times 4\frac{1}{2}$ inches, the half of which are contained in a space of 5 inches. The enamel is not particularly thick for the size of the tooth, but the ridges are very high for a molar of the Mammoth, the eighth ridge being 8 inches in height. The disk presents all the features of the crown of the species in question as distinguishable from *E. meridionalis* or *E. antiquus*. Although no history is attached to the specimen it was evidently either dredged up or found on the shore.

Another broken tooth, but evidently of enormous size, is represented by a fragment in the British Museum, from Fenny Stratford, Essex. It holds x 12 in $7 \times 4\frac{1}{2}$. Here the enamel is *thin* and the cement scant, but the dentine is in excess, causing unusual width of the plate. There is likewise a large tusk in the Museum, from the same locality, to which I have already referred to at p. 82.

In Mantell's Collection, British Museum, there are several true molars, none of which are entire, from a raised beach at Brighton, Sussex. All are deeply impregnated with chalk. They evidently belonged to *thick-plated* teeth of very large dimensions. But a fragment of a true molar from "gravel (?) Brighton," in the Museum of Practical Geology, has *thin* enamel with rather an excess of cement, and holds eight in $3\frac{1}{4}$ inches.

A very large molar is instanced by the fragment of an upper molar from Oundle, Northamptonshire, in the British Museum. It has none of its collines invaded, and holds x 19 in $11 \times 4\frac{1}{2}$ inches. The plates are *very thick* with excess of cement.

Another broken tooth in the same Museum, from Northampton, has x 19 in 10×2 inches, and holds eight in 4 inches. Like the preceding it is characterised by its *thick* plates and abundance of cement. The crown is arcuated a good deal, and the tooth may have belonged to the mandible of the foregoing.

I examined very carefully the imperfect ultimate upper molar in the Woodwardian Museum, stated by Falconer to belong to "the *pre-glacial* variety of *Elephas primigenius* from the Norwich Coast."[1] Assuredly, the matrix with which it is intimately encrusted is indistinguishable from that on the crowns and palate of a superb specimen of the ultimate molars of *E. meridionalis* and other teeth of the latter "from the Forest Bed," in the Woodwardian Collection.[2] Whether or not certain *post-glacial* beds, as I believe

[1] 'Pal. Mem.,' vol. ii, p. 170. Falconer further substantiates his belief in the Mammoth having been *Pre-glacial* by statements elsewhere (see 'Pal. Mem.,' vol. ii, p. 240).

[2] Professor Boyd Dawkins points out instances similar to the above from the Forest Bed at Bacton,

has been suggested, were derived from the "Forest Bed," there can be no question whatever as to the correctness of Falconer's diagnosis of the above molar. It has clearly the typical crown of the Mammoth, with rather *thin* enamel, according to my experience, whilst Falconer says "slightly thick." He observes, moreover, that the plates are "perfectly free from crimping." This is not apparently quite the case, as there is a little crimping towards the middle of the machærides.

The tooth is about $11\frac{1}{2}$ inches in length by about 4 inches in width, and contains eighteen ridges, and eight ridges in 4 inches. It represents that of an aged individual, and only wants the assurance of its reputed origin to establish the existence of *E. primigenius* in *pre-glacial* times.

A *thick-plated* tooth in a fragmentary condition from "blue clay at Lawford, near Rugby," is in the University Museum, Oxford. It holds 19 *x*, and contains eight ridges in 4 inches. The thickness of the plates here appear dependent on a general increase of the crown constituents, and not of one element in particular.

In the Museum of Science and Art, Dublin, there is a mutilated molar of the upper jaw of the Mammoth, received from the "Black Sea." Unfortunately there is no further history attached to it, but my friend Dr. Carte, M.R.I.A., Conservator of the Museum, is of opinion that it was presented to the collection by an officer during the Crimean War. It has evidently been dredged, as it contains shells of *Cirripedia* and cells of *Flustra* on its outer surface. There is a loss of plates behind as well as in front, so that its exact position in the series cannot be accurately defined. It holds thirteen plates in $4\frac{1}{2}$ inches. The enamel is very *thin* and altogether similar to the very *thin*-plated Arctic molars.

There is a fragment (No. 10) of a last molar, containing about twelve plates, in the Woodwardian Museum, from the "Valley of the Danube." Its enamel is somewhat *thick*.

Two lower teeth, No. 572 of the Museum of the Royal College of Surgeons, from Bridport, Dorsetshire, are remarkable for their narrow crowns and *thick* plates, and contain 19 *x* in 11×3 inches. There are eight ridges in 4·2 inches.

A fragment from the "Isle of Dogs," near mouth of the Thames, is in the British Museum. It is stated to have been procured from a peaty deposit. The enamel is *thin*, and eight ridges are contained in 3 inches.

Another broken tooth, showing very closely packed plates and *thin* enamel, is in the same collection. There are nineteen ridges; and eight ridges in only $2\frac{1}{2}$ inches. The specimen is evidently that of an ultimate molar, and was found in gravel at Ballingdon, in Hertfordshire.

Norfolk Coast, 'Quart. Journ. Geol. Soc.,' vol. xxviii, p. 418. I must here correct a surmise made by me with reference to the above molar in supposing that the specimen was probably the broad-crowned variety of *E. antiquus* ('Monograph on *E. antiquus*,' note 1, p. 40). This supposition, after having examined the specimen, which I had not seen at the time, I now fully admit was wrong.

Another lower ultimate tooth in the British Museum, from Walthamstow, Essex, holds twenty-two plates in $10\frac{1}{2} \times 3$ inches and eight in $4\frac{1}{2}$ inches. This a *thick-plated molar*, but the cement is also in excess.

A lower ultimate in the British Museum, from the Thames near Brentford, Middlesex, has twenty-one of the anterior ridges remaining in $11 \times 2\frac{1}{2}$ inches, and contains eight in 5 inches. The plates are *very thick*, with much cement. The crown is narrow and much arcuated.

A mutilated lower ultimate molar, holding x 18, from the "post-pliocene," Dartford, Kent, is in the Museum of Practical Geology. It is noteworthy for its very thick plates and crimped enamel; the latter, however, is not abnormal as regards thickness, but the dentine and, chiefly, cement are in excess.

An imperfect crown from gravel at Chesterton, Cambridgeshire, in the Woodwardian Museum, presents *thin* enamel, which is crimped. There are from twenty to twenty-one plates, besides a posterior talon, in $8\frac{1}{2} \times 3$ inches, and eight ridges are contained in a space of 2·8 inches. There is also a fragment of a tusk from the same locality. The molar contrasts, as regards the thickness of its plates, with a milk molar from the same situation, described at p. 97, whose plates are decidedly *thick*, whilst both indicate small individuals of their respective ages as is seen in the Ilford molars.

The Museum of Zoology, Cambridge, contains a fragment of an ultimate molar holding fourteen collines in 7×3 inches. It is interesting as being from Whitby, in Yorkshire. The crown is *typical*.

The same collection contains a fragment of a true molar from Wenden, in Essex, with a *typical* crown pattern, and another fragment from "valley gravel," Bocking, Essex, with rather *thick* enamel; also a piece of a last molar from Buxton, Derbyshire, and also a broken tooth from gravel at Kensington, London, containing eight ridges in $3\frac{1}{2}$ inches. The plates in the last-named tooth are rather *thick*, with the enamel like that in Ilford molars, whilst two other specimens from the "brick-earths" at Sittingbourne, Kent, are *thin*-plated, both the enamel and cement being thin.

An incomplete true molar, possibly an ultimate, recorded from "Compton Bay, Isle of Wight (Forest Bed)," is in the Jermyn Street Collection. It is *thick*-plated at the expense of the enamel, which is inordinately *thick*. There is also a germ of either an ultimate or penultimate in the same collection from "Freshwater Gravel, Chale Bay, Isle of Wight." The characters of this tooth are not determinable with certainty.

A fragment of one or other of the last of the series from Kent's Cavern is in the British Museum. It shows, as has been already noted, *thin* enamel (p. 94) with faint crimping of the disks.

There is an imperfect right lower last true molar from Barrington, in the Woodwardian Museum, Cambridge, containing 17 x in $11 \times 2\frac{3}{4}$ inches. All the elements of the crown are in excess, the cement in particular, and the disks present crimping with

central dilatation, like as in *E. antiquus*, but not to the extent at all likely to lead to a doubt as to the species to which the molar belonged.

Among the foreign molars in the British Museum is a fragment of a last lower molar from SIBERIA, in the Sloane Collection. It is noteworthy for the *thick* enamel and cement in an Arctic specimen, there being eight ridges in $4\frac{3}{4}$ inches.

A good instance of the deformities to which ultimate molars of Elephants are subject is represented by a remarkable abnormality in a molar in the British Museum, from ESCHSCHOLTZ BAY, the plates being rolled up like a "roly-poly" pudding.[1]

In the Woodwardian Museum there is a very large ultimate upper molar containing about twenty-four ridges, with the hinder ones also doubled on the side of the heel, as in the foregoing specimen. This is the tooth referred to in Dr. Falconer's 'Palæontological Memoirs,' from some entry in a note-book, wherein he is stated to have written that the above-mentioned molar "bears all the marks of having died in captivity in the service of man of the flint-knife period."[2] This would, of course, imply that Falconer held a belief that the man of the Stone Age had probably reclaimed the Mammoth, but a subsequent explanation (pp. 281 and 285 of his paper "On the food of Elephants") shows clearly that the deformity in question is ascribable to causes not necessarily dependent on captivity, as might be readily supposed. The tooth is otherwise typical of the Mammoth; its locality however, is unknown. I fail, therefore, to notice any further character which could in any way account for the above statement, which, after all, was merely the jottings-down of a memorandum book, and might have been judiciously omitted in transcribing his notes.

A curious and interesting specimen of an excessively worn ultimate molar of the Mammoth was brought to my notice by Professor McKenny Hughes in the Woodwardian Museum. The ridges were nearly ground to their enamel reflections, the plates being nearly all converted into insular-shaped loops on the surface of dentine, whilst the fangs had become consolidated into a ridge running alone the base of the crown like the keel of a vessel. It is a lower tooth of the right side. It moreover serves well as an illustration of the state of knowledge of proboscidean anatomy one hundred and fifty-three years ago, as may be inferred from the following entry in 'A Catalogue of the Foreign Fossils in the Collection of J. Woodward, M.D.,' part 2, μ 23, July, 1725, London, in which the above is described, p. 40, "as a very large grinder of some cetaceous fish, weighing . . . perfect, and entire; dug up in the DUCHY of WIRTEMBERG."

Mr. Davies showed me a drawing of a lower last true molar, in the possession of Mr. Dawson, of Beccles, Suffolk, in which only three small rounded islands of enamel remain in a mass of dentine $7\frac{3}{4} \times 2$ inches in breadth. The height of the ivory base is

[1] The very fine specimen of the lower ultimate molar of the Asiatic Elephant, 'Brit. Fossil Mammals,' fig. 90, shows a similar deformity, which is repeated in various teeth of recent and fossil species, such as those shown in pl. vii, fig. 6, and pl. ix, fig. 6, of De Blainville's 'Ostéographie.'

[2] Vol. ii, p. 169.

$4\frac{1}{2}$ inches, and indicates that the latter had been increased when the ridges were being worn out. The interesting fragment from Parkinson's Collection in the Museum of the Royal College of Surgeons, and figured by him and Professor Owen, is equalled by nearly a precisely similar fragment, No. 3448 of the Kent's Cavern Collection, lately sent to me for examination by Mr. Pengelly. These teeth attest the extreme age attained by the animal.[1]

The two North-American molars, figured and described by Cuvier,[2] one from near the mouth of the "Mississippi," the other from "Bigbone Lick," Kentucky, show, as in the lower molar from Siberia, described at p. 117, very evident traces of having been much rolled. Neither specimen was seemingly entire. One of these contains twenty-two ridges, and presents precisely the same *thin*-plated characters of the foregoing and the molars from Behring Strait and the Arctic Circle generally.

There are two fragments of true molars, possibly ultimate teeth, in the Woodwardian Museum, from "Bigbone Lick, Kentucky," bearing the peculiarly Arctic aspect of the above, in the enamel being *very thin*. Like the Ohio molars the specimens are blackened, as obtains also in Mastodon remains from the latter State, as if all had come out of peat. A fragment from the same locality is in the British Museum, and as far as appearances go is indistinguishable from the foregoing.

Mandibles with teeth in situ.—There are two mandibles in the British Museum of very old Elephants, in the Owles Collection, from the Dogger Bank. One is No. 46,197, and shows (as in Plate VIII, fig. 3, from Ilford) the usual characters of ultimate teeth in containing more cement externally than in the preceding teeth, for the reason that this material is needed to fill up the space between the tooth and the jaws. In the former the round heel is nearly level with the border of the coronoid, and, although the jaw is broken across immediately behind, a considerable fragment of the cancellated plug remains where, in the case of a second or any other member of the dental series, the crown of a successor would have appeared. The crowns of the molars are detrited to the common base in front, and only twelve plates and posterior talon remain. The rostrum in this specimen is conspicuously long (Woodcut, fig. 23, p. 139), being over 3 inches in length, and the antero-posterior diameter, including the spout, is 11 inches. The mental foramina (Woodcut, fig. 9, p. 135) are further apart from the free margin of the diasteme than usually obtains in the species. The jaws are thick, being about 6·2 inches at the base of the coronoid, and the height of the symphysis is 4·2 inches. The teeth converge a good deal, being 4 inches apart in front, 5 at the middle, and 8 behind.

The other mandible, No. 46,215, B. M., shows molars with *very thick* enamel and much cement as compared with the usual crown from the Dogger Bank. Here the mental foramina are also unusually irregular, there being four on the right and three on the left, at irregular distances relatively to the border of the diasteme. The tooth is

[1] 'Organic Remains,' pl. xx, fig. 7; 'Brit. Fossil Mammals,' fig. 95.

[2] 'Ossemens Fossiles,' vol. ii, p. 181, and pl. xv, figs. 9 and 11.

more detrited than the preceding, having lost a few more plates, and the heel is level with the anterior border. There is no rostrum, only a slight beak, with the borders of the diasteme running down to a point in front of the chin, to meet and form the chevron-shaped front shown in the Woodcut, fig. 7 (p. 135).

The molars from the Arctic regions, although very characteristic on account of the extreme tenuity of their enamel, exhibit exceptional instances, which, with similar cases from British and European localities, seem to me to point to the *thick*- and *thin*-plated teeth as being often casual differences and individual peculiarities. A mandible in the British Museum, from Eschscholtz Bay, a front and profile view of which are shown in Woodcut, fig. 5 (p. 135), is referred to by Buckland in the Appendix to Beechy's 'Voyage of the Blossom.' It has lost a portion of the right ramus, and both of the coronoid processes, otherwise the jaw is entire. This mandible is typical of the Arctic specimens. The dental canal is large, gaping, and opens directly upwards, with a small projecting spine on its anterior border. The condyle and its neck viewed from behind show a pronounced concavity on the inner border of the latter, but it is not so deep as in the Asiatic, yet it has the prominent crotchet which seems very general in the Asiatic as pointed out by Busk, and considered by him to be characteristic of that species.[1] The height in front of the molar is $6\frac{1}{2}$ inches, and maximum width of the ascending ramus at the base of the coronoid is $6\frac{1}{2}$ inches. The front portions of the teeth are ground down, leaving thirteen plates with a projecting heel in $8\frac{1}{2} \times 3\frac{1}{4}$ inches, whilst eight plates occupy a space of $4\frac{1}{2}$ inches. The plates here are *thick*, and the machærides *crimped*, such as are not common in Siberian and North-American molars. The breadth in front between the teeth is $2\frac{1}{4}$ inches, at the middle 5 inches, and posteriorly $7\frac{1}{2}$ inches. The elevated and rounded heel is just half an inch behind the anterior border of the coronoid, yet the part of the ascending ramus behind is made up of spongy and cancellated bone without any appearance of plates. This must have been a very old Elephant.

There is another mandible of Siberian origin in the British Museum, holding two well-worn ultimate true molars; the rounded heel, however, is 3 inches behind the anterior border of the coronoid, and quite flattened, as in the preceding, with a space[2] of 7 inches between it and the entrance to the dental canal. Mr. Davies caused, as in the preceding, an incision to be made in the back portion of the ascending ramus, but without meeting with a trace of a colline, and only the spongy septum present, made up

[1] 'Trans. Zool. Soc. London,' vol. vi, p. 237.

[2] The position of the heel of the molar in wear with reference to the anterior border of the coronoid will readily indicate to the student the state of advancement he may expect of the successional tooth, as shown by numerous beautiful examples in the rich and instructive collection of the Royal College of Surgeons. In a nearly similar instance to the above in the Asiatic Elephant the second true molar has thirteen of its anterior ridges invaded, and heel two inches behind the anterior border of the coronoid, whilst the vault of the third molar is just broken through, and the collines are lying loose in their capsule. See also the mandible of the Mammoth with the first true molar in full wear in the 'F. A. Siv.,' pl. xiii A, fig. 2, and that of *E. Hysudricus*, fig. 7.

of spiculated particles of cancellated bone, and earthy material.[1] There is a loss by dentrition of the fore part of each molar, which holds 13 x in $9 \times 3\frac{3}{4}$. The enamel is *thick*, with much cement and some crimping of the machærides ; indeed, eight ridges are contained in $4\frac{3}{4}$ inches, which show the great thickness of the plates as compared with the usual crowns from the Arctic regions.

The molars converge considerably, being 2·9 inches apart in front, $3\frac{3}{4}$ at their middle, and $3\frac{3}{4}$ posteriorly. The ramus is 7 inches in thickness at the base of the coronoid. The jaw has all the characters of that of the Mammoth already noticed.[2]

Another nearly entire mandible in the British Museum, dredged off Harwich, presents some rather remarkable peculiarities. The two molars are in full wear, with a loss of some ridges in front by detrition, without a trace of a third tooth in the cavity posteriorly, as proved by inspection, although the round prominent heels are elevated, and $2\frac{1}{2}$ inches behind the anterior border of the coronoid.[3] Each molar holds seventeen plates in $10\frac{1}{2} \times 3\frac{1}{2}$ inches, and is considerably arcuated and converges; the distance between them in front is 3 inches, at the middle $3\frac{1}{2}$, and behind $7\frac{1}{2}$ inches. The maximum length of the jaw from the posterior border of the ascending ramus 20 inches. Height in front of the molar $8\frac{1}{2}$ inches. Maximum thickness of the ramus $6\frac{1}{2}$ inches. Maximum expanse of the jaw at the middle of the ascending ramus 20 inches. The diasteme is perpendicular.

The numerous molars of the Mammoth derived from peat at Lexden, near Colchester, Essex,[4] several of which have been already noticed, point to the fact that the *thickness* or *thinness* of the enamel cannot always be depended upon as characteristic of races or local varieties, although, as has been shown, it is peculiarly *thin* in Arctic and the so-called Ohio and North-American molars, as well as in many teeth from British strata.

The mandible (No. 95, Fisher Collection) in the Woodwardian Museum contains two ultimate molars from Lexden. The teeth are very much detrited, indeed, they are nearly worn out, seeing that the heel is only an inch behind the anterior border of the coronoid. The rami are lost just behind the teeth, but a fragment of the plug remains in the space which a succeeding molar would have occupied. Only eleven to twelve

[1] In the mandibles (2674 and 2664) of Asiatic Elephants in the Museum of the Royal College of Surgeons of England, the heels of the first true molars, which are in full wear, are almost in line with the anterior border of the coronoid, whilst the second has four collines appearing above the gum, and six visible, but none are nearly on a level with the grinding surface of the tooth in use.

[2] The portion of a mandible with two molars holding thirteen worn plates is well shown in the 'Fauna Antiqua Sivalensis,' pl. xiii A. The teeth are of such gigantic dimensions that I cannot help assigning their age to be exactly as represented by the Siberian jaw just noticed, *i. e.* an ultimate molar more than half detrited. Falconer had not evidently made up his mind on that subject, 'Pal. Mem.,' vol. i, p. 439.

[3] The mandible 2675 (Asiatic Elephant), Royal College of Surgeons Museum, has the second true molar with twelve to thirteen ridges invaded, and the heel two inches behind the anterior border of the diasteme. The vault of the third molar is broken through, and the tips of the collines are just visible.

[4] See p. 110.

plates remain in a space of $7 \times 2\frac{1}{2}$ inches. The enamel is *thick*, as is generally the case in the ultimate molars of small individuals as the above must have been. Measured along the surface in wear, eight ridges are contained in $4\frac{3}{4}$ inches. The height in front of the molar is $6\frac{1}{2}$ inches. The greatest expansion of the rami at the angle is $17\frac{1}{2}$ inches, and the maximum thickness of each is $5\frac{3}{4}$ inches. The teeth converge, being 3 inches apart in front, 4 inches at the middle, and $7\frac{1}{2}$ inches behind.

There are fragments of other true molars in the collection from the same locality, showing *thick* and *thin* enamel. One, evidently portion of a lower last tooth, has decidedly *thin* enamel. Associated with the above is a cuboid and a fourth metatarsal; the former is $3{\cdot}6 \times 3{\cdot}4$ inches, and the latter is 4 inches in length. Teeth of *Rhinoceros leptorhinus* (Owen ?) are preserved also from the same peaty deposit.

The nearly entire mandible (Pl. VIII, fig. 3) described by Davies[1] shows the last true molar nearly half worn. The ultimate tooth, for its length and number of ridges and the usual tectiform contour of the upper surface, lasts very much longer than any of the preceding molars. At all times it represents senility, the degree of which becomes excessive when the crown is so ground down that its heel, rising above the level of the alveolus, is in front of the anterior border of the coronoid. Then the part of the ascending ramus becomes filled by a plug of cancellated bone, which runs up to the opening of the dental canal.

No member of the dental series varies more in the number of ridges than the ultimate molar of the Mammoth. Dr. Falconer does not seem to have come across a specimen with a lower ridge formula, at all events in the upper jaw, than *x* 22 *x*,[2] or a higher than *x* 26 *x*, the prevailing number being *x* 22 *x*. Taking all the materials which have come under my notice, I find of perfectly entire teeth the following ridge formulæ :

	x 18 *x*	*x* 19 *x*	*x* 20 *x*	*x* 21 *x*	*x* 22 *x*	*x* 23 *x*	*x* 24 *x*	*x* 25 *x*	*x* 26 *x*	*x* 27 *x*	*x* 29 *x*
Upper Molars	4	5	7	8	4	4	5	0	2	1	1 (?)
Lower Molars	1	3	5	1	4	3	1	0[3]	0	0	

According to the foregoing and numerous other specimens not so entire it appears to me that the ridge formula varies *constantly* between *x* 19 *x* and *x* 24 *x*, so that it is difficult to say what is the prevailing number. It may vary possibly between twenty-two or twenty-three plates besides talons. Many Arctic molars, like the incisors, attain to very large dimensions, and the thinner the plates the greater the number, and *vice versâ* ; the rule, however, is not absolute.

[1] 'Cat. Brady Collection,' p. 11, $\frac{c}{49}$. [2] 'Pal. Mem.,' ii, p. 168.

[3] The higher expressions in lower molars requiring a considerable length of crown would be very subject to injury, and this is the case more or less with many of the lower teeth when they attain a length beyond 9 to 12 inches.

The last true molar of the Asiatic Elephant attains not unfrequently to the maximum limit of that of the Mammoth, but I have not seen an entire tooth with a lower ridge formula than *x* 20 *x*, whilst the average is about *x* 22 *x*. Indeed, although the Asiatic Elephant goes hand-in-hand in all its leading characters with the Mammoth, it maintains more regular averages of the various members of the dental series than the latter.

The affinities, therefore, between the ridge formulæ of the Mammoth and the Asiatic Elephant are of the most intimate character, and there seems a close relationship in that respect between the last and *E. Armeniacus* and *E. Columbi*, which are apparently closely correlated, not only as regards the ridge formulæ, but also the morphological characters of their grinders. Dr. Falconer was impressed with the relationship between the former and the Asiatic Elephant, but considered the latter Elephant to be "between *E. antiquus* and *E. Indicus*."[1] I must observe, after repeated comparisons of the dental materials of *E. Armeniacus* and *E. Columbi*, available in the British Museum and Royal College of Surgeons, with those of *E. Asiaticus*, *E. primigenius*, *E. antiquus*, *E. Namadicus*, and *E. Hysudricus*, that I fail to distinguish distinctive characters of any value between the molars of the Asiatic and the so-called Columbian or American and the Armenian Elephants; so that, as far as teeth are concerned, the existing species may be the survivor of an Elephant whose fossil remains have turned up in Italy (?), Turkey in Asia, and throughout the temperate regions of North America.

The last molar of *E. antiquus*, especially the broad-crowned variety, might be mistaken for that of the Mammoth, and the same might be said of the *E. meridionalis*; and although the ridge formulæ might not be of assistance as regards the diagnosis with reference to the two former, still, in entire specimens and in crowns sufficiently detrited to show the pattern, I can scarcely conceive that in practised hands there would be much difficulty with reference to *E. meridionalis*. The lower ridge formula of the latter, apparently rarely rising above seventeen ridges altogether, with the massive proportions of the crown constituents, and its absence, with doubtful exceptions, from the deposits in which Mammoth remains are found, render its molars of easier distinction.

The ridge formula of the Mammoth, according to the latest differentiations made by Falconer, stood thus after eliminating talons:

Milk Molars.			*True Molars.*		
4	8	12	12	16	24

He maintained a theory that these figures were expressive of the usual number of plates in the six molars. Now, were the above in any ways general, their use as exponents of the ridge formula of the species would at all events be of taxonomial value. But from the data here furnished this must appear questionable, and I have no hesitation in stating that, were the collections on the Continent of Europe carefully examined, the range of the ridges in each member of the series might be further extended.

[1] Op. cit., vol. ii, pp. 447 and 214.

In my 'Monograph on *E. antiquus*,' I showed a similar variation and inconstancy in the number of ridges in its molars. I had not then, however, made a close study of the teeth of *E. primigenius*, whose ridge formulæ, according to the results of late researches, appear to me to stand as follows:

(*Elephas primigenius.*)

	Milk Molars.				*True Molars.*		
	I.	II.	III.	IV.	V.	VI.	VII.
Upper Molars	$\frac{?-?}{x\ 2\ x-}$	$+\frac{x\ 3\ x-x\ 4\ x}{x\ 3\ x-x\ 4\ x}$	$+\frac{x\ 6\ x-x\ 9\ x}{x\ 6\ x-x\ 9\ x}$	$+\frac{x\ 9\ x-x\ 12\ x}{x\ 9\ x-x\ 12\ x}$	$::\frac{x\ 9\ x-x\ 15\ x}{x\ 9\ x-x\ 15\ x}$	$+\frac{x\ 14\ x-x\ 16\ x}{x\ 14\ x-x\ 16\ x}$	$+\frac{x\ 18\ x-x\ 27\ x\ (x\ 29\ x\ ?)}{x\ 18\ x-x\ 27\ x\ (x\ 29\ x\ ?)}$
Lower Molars							

(*Elephas antiquus.*)

	Milk Molars.			*True Molars.*		
	II.[1]	III.	IV.[2]	V.	VI.	VII.
Upper Molars	$\frac{x\ 2\ x-x\ 3\ x}{x\ 3\ x-\ ?}$	$+\frac{x\ 5\ x-x\ 7\ x}{x\ 6\ x-x\ 8\ x}$	$+\frac{x\ 8\ x-x\ 10\ x}{x\ 9\ x-x\ 11\ x}$	$::\frac{x\ 9\ x-x\ 12\ x}{x\ 11\ x-x\ 12\ x}$	$+\frac{x\ 12\ x-x\ 13\ x}{x\ 12\ x-x\ 13\ x}$	$+\frac{x\ 15\ x-x\ 20\ x}{x\ 16\ x-x\ 19\ x}$
Lower Molars						

IV. OSTEOLOGY.

I. CRANIUM.

The skull of the Mammoth presents much closer affinities to that of the Asiatic than to the African Elephant, or, indeed, any other proboscidean, as far as is known of their skeletons. This opinion, enunciated by Cuvier, has received further confirmation since his time. He characterised the skull of the Mammoth from that of every other species of Elephant then known to him, by the following:—1. A lengthened cranium. 2. Concave forehead. 3. Very long incisive alveoli. 4. Obtuse lower jaw. 5. Large grinders with closely packed and parallel laminæ.

[1] The presumed presence of the pre-ante-penultimate milk molar requires the numbers to be arranged accordingly. It is here believed that the $x\ 2\ x$ in the upper jaw of *E. antiquus* represents the minimum ridge formula in the second or ante-penultimate, whilst the so-called pre-ante-penultimate or first milk molar shown in the ridge formula of the Mammoth has not hitherto been recognised in *E. antiquus*.

[2] Just lately a molar came under my notice in the Museum of Zoology, Cambridge, from the "gravel" in the neighbourhood, with so low a ridge formula as $x\ 8\ x$ in 3·9 inches. I therefore make this alteration in the ridge formula as given at p. 47 of my Monograph.

Cranial contour.—Conjointly these foregoing characters are fairly distinctive of the Mammoth (Pl. VI, figs. 1 and 1 *a*), and broadly so as compared with the short-crowned Elephants, such as the African species, and seemingly *E. meridionalis*, an entire skull of *Elephas antiquus* not being known ; but the crania of certain Sewalik Proboscidea, to wit, *E. planifrons* (African-like ?), *E. insignis*, *E. bombifrons*, as far as their fossil remains permit one to judge, were very different from the long-crowned Mammoth and Asiatic Elephant, to which *E. Hysudricus*, with its distorted (? deformed) forehead, might be added. Consequent on these short and long cranial vaults the length from the vertex to the extremities of the premaxillaries, as compared with the breadth of the forehead at the post-orbital processes, varies considerably. Cuvier estimated the measurements in the two recent species as 5 to 3 in the Asiatic, and 3 to 2 in the African, and these appear to me from various measurements to be pretty general. The skull of the Mammoth agrees with the former, whilst according to Falconer and Nesti, that of *E. meridionalis* seems to come closer to the latter. No skull of *E. antiquus* being, as far as I know, yet described, we can only make comparisons with its very close Eastern representative, *E. Namadicus*. Supposing the extraordinary frontal rim of its calvarium in the British Museum[1] was absolutely of the character and extent shown in the specimen, and not the result of pressure or injuries after death, there never would be much likelihood of confounding it with the above, or in fact any other known proboscidean.

The configuration of the vertex and degrees of depression, flatness, and convexity of the forehead seem to differ widely in different species of Elephant.

The vertex in the Mammoth rises high, like that of the Asiatic Elephant, but it is decidedly narrower, and the pronounced depression in the recent species is not apparently so deep in the Mammoth. This is well seen in Pl. VII, figs. 1 and 1 *a*, and also in a cast of a nearly entire cranium from Brussels, in the Museum of the Royal College of Surgeons, London.[2] In *E. meridionalis*, according to Nesti, and as stated by Falconer, the posterior border of the vertex is transverse, the occipital fossa, of which the depression is the upper termination, being over-reached by a produced fold of the vertex.[3] The so-called "bonnet-shaped summit" of the cranium of *E. Namadicus* just noticed is still more peculiar, whilst the broad circular crown of the African distinguishes it from any of the foregoing, and assimilates its characters rather with *E. planifrons* and *E. bombifrons*.

Frontal depression.—The Mammoth's skull presents a slight depression or concavity of the forehead, with a small prominence above it. This is very evident in the Brussels skull, and although the part is somewhat injured in that from Ilford (Pl. VII, fig. 1) it

[1] 'Fauna Antiqua Sival.,' pls. 12 B and 24 A.

[2] A well-preserved cranium of the Mammoth is very rare considering the enormous quantities of its teeth and bones discovered throughout Europe. Dr. Falconer (1865) knew of only one entire specimen out of Russia. Besides that, two nearly entire skeletons in the Royal Museum of Brussels, a skull of which is here referred to, and the Ilford cranium, pls. VI and VII, are the only instances known to me.

[3] 'Pal. Mem.,' vol. ii, p. 122.

is quite apparent also in the latter.[1] Evidently, as in the Asiatic, where a similar sinking exists, it varies considerably with age, and is deeper in some individuals than in others; and varies, no doubt, also in the sexes. *E. ganesa* and *E. insignis* show also slight depressions in the same situation. It is more pronounced in drawings of *E. meridionalis;* whilst the beetling crown of *E. Namadicus* is quite unique; and the excessive sinking in the forehead, amounting to a cranial deformity in the skull, of *E. Hysudricus*, in the British Museum, as compared with the perfectly even surface of the part in the adolescent cranium of the same species by its side, suggest the probability that the former may have undergone compression some time after death.[2]

Again, the forehead is flat in the young of *E. Africanus*, becoming slightly convex in the adult and aged. *E. planifrons* and *E. bombifrons* appear to have also flat frontals.

Breadth of forehead.—The breadth of the forehead at its narrowest part between the temporal ridges varies apparently in the insular and Continental varieties of the Asiatic Elephant, but the Mammoth agrees better in the character with the Asiatic than any other species. This part seems broadest in the short-headed Elephants, to wit, *E. Africanus*, and *E. planifrons*, gradually narrowing through the two preceding, and *E. Hysudricus*, and *E. meridionalis* to *E. bombifrons*, where the forehead is excessively narrow as compared with the crown and occiput.

Nares.—The outline and position of the narial aperture are similar in both the Asiatic Elephant and the Mammoth. It is generally reniform in shape, with the horns directed forwards; the latter character, however, does not seem invariable in the Mammoth, and is reversed in young crania of the recent species, whilst the configurations of the apices of the cornua are more circular in certain individuals than in others. But these characters are not confined to the above species, being more or less observable in *E. Africanus*, *E. meridionalis*, *E. Namadicus*, &c. The aperture, however, is placed at about the same relative distance from the vertex in the Mammoth and Asiatic Elephant, whilst it is nearer to the crown in the African *E. meridionalis*, *E. Namadicus*, and other brachycephalic species. It is a part, however, so liable to injury in the fossil skull that one rarely meets with it in a state of integrity.

Incisive sheaths.—Dr. Falconer states that the incisive alveoli of the Mammoth form an angle with the frontal plane, thereby necessitating the truncation of the mandible at its symphysis.[3] This is somewhat apparent in the Brussels skull, and, although the

[1] This hollow is also evident in the Siberian skull shown in pl. xiv, fig. 2, and in the cranium of Adams's skeleton, pl. xvii, of the 'Ossemens Fossiles.' The skull etched on the fragment of ivory from the Cave of La Madelaine, in the Dordogne, is so truthful that, supposing we had never seen a Mammoth's skull, there could be no difficulty whatever in at once differentiating the characters of the profile of the above from that of either of the recent species, at all events from the African Elephants. This essay of an artist belonging to the early stone age of Southern France is assuredly a most laudable performance.

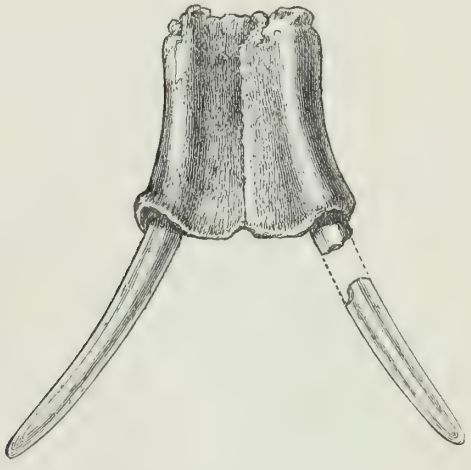
[2] Compare pl. xlv, fig. 20 A, with fig. 20 B of the 'Fauna Antiqua Sivalensis.'

[3] 'Pal. Mem.,' vol. ii, p. 121. The same is stated to obtain in the *E. ganesa*, famous for its enormous incisors.

supports are a good deal in the way of seeing it in the Ilford specimen, the same appears to me to be slightly indicated in the latter also (Pl. VI).[1] In neither, however, does it appear so pronounced as to produce a decided inflection of the premaxillaries. Nothing, however, of the kind seems present in numerous skulls of the two recent species examined by me. In *E. meridionalis*, Falconer states that the alveoli "are produced in the same plane, or with a little obliquity;"[2] and *E. Namadicus* maintains to all appearances the same character.

The parallelism of the massive alveoli in the Mammoth is dwelt upon by Falconer as characteristic, in comparison with *E. meridionalis*, where, instead of being parallel, "they diverge from the sub-orbitary foramina on to their extremity, where the divergence becomes sudden and as marked as in the African Elephant."[3] Now, although the divergence of the alveoli is not so pronounced as in either of the two living species, nor apparently as in *E. meridionalis*, it is clear that the alveoli are also not parallel in the Mammoth, but tend in opposite directions gradually from their commencement towards the extremities of the premaxillaries, where they diverge rapidly. This disposition to divergence in the alveoli of the Mammoth is further seen in the accompanying Woodcut, fig. 1 ($\frac{1}{12}$th natural size), from Ilford. It represents the third milk stage of dentition, as proven by its three molars preserved with the specimen in the Museum of Practical Geology, to which I have referred at page 94.

Fig. 1.



From Ilford: Museum of Practical Geology.

The same is seen in Plates VI and VII of the skull from the same locality. Here the right alveolus has been considerably injured, but has been restored carefully by the artist from the left side, which is entire. The cast of the skull from Brussels, in the Museum

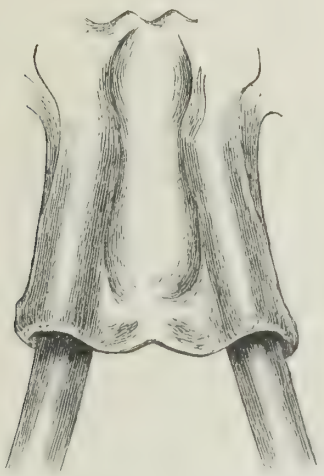
[1] Compare also the Siberian cranium of the Mammoth, 'Ossemens Fossiles,' pl. xiv, fig. 2*f*, with that of *E. meridionalis*, pl. xv, fig. 1.

[2] Op. cit., vol. ii, 125.

[3] Op. cit., vol. ii, p. 124.

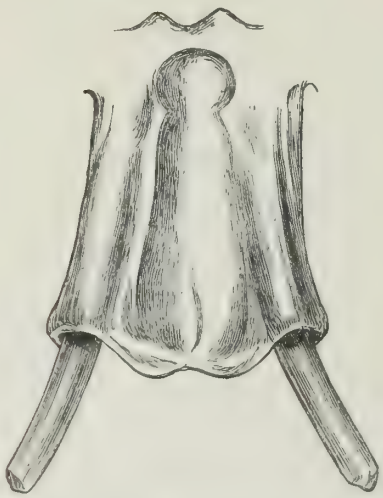
of the Royal College of Surgeons, also repeats the above-mentioned character. The intervening hollow, which, of course, varies with the size of the tooth, becomes broader and shallower towards the alveolar border. The decided parallelism of the tusks of *E. ganesa*, not only in their sockets, but for some distance beyond, is remarkable as compared with other fossil species. No doubt there were individual differences, as obtain in the Asiatic, where the divergence is sometimes more pronounced, in such as the Dauntela Elephant of Corse, in the British Museum, and the celebrated Choone (Asiatic), and an African in the Hunterian Museum, Royal College of Surgeons (Woodcuts, figs. 2 and 3). The alveolar divergence is pronounced also in the skull of *E. Namadicus*.[1]

Fig. 2.



E. Asiaticus, Choone (No. 2654, in Collection of Royal College of Surgeons).

Fig. 3.



E. Africanus (No. 2845, in Collection of Royal College of Surgeons).

Sub-orbital foramen (Pl. VII, fig. 1 *a*) is apparently larger in the Mammoth and Asiatic than in the African. The part is not sufficiently well preserved in other fossil crania to allow of comparison.

The *post-orbital process* (Pl. VI, figs. 1 and 1 *a*) is more lengthened, pointed, and hooked in the Mammoth than in the recent species, but it is more so apparently in the Asiatic than in the African. Falconer states that this process in the *E. meridionalis* is "like that of the Mammoth."[2]

The *lachrymal tubercle*, as pointed out by Cuvier, is more prominent in the Mammoth than in the Asiatic, where it is apparently less projecting than in the African. It is pointed in *E. meridionalis*, according to Falconer.[3]

The *zygoma* in the Mammoth (Pls. VI, VII) and in *E. Asiaticus* is just below the condyles; whilst it is much lower in *E. Africanus*, *E. meridionalis*, *E. Namadicus*, and

[1] 'F. A. Sival.,' xxiv A, fig. 4. [2] 'Pal. Mem.,' vol. ii, p. 123. [3] Idem, p. 123.

the other short-crowned Elephants. It is, moreover, nearly parallel with the molars in the Mammoth and Asiatic Elephant, whereas, according to Falconer, this arch in *E. meridionalis* inclines to that of the molars, at an angle of about 35°.[1] The enclosure formed by the zygomatic arcade, as viewed from below, is circular in the African and ovoid in the Mammoth (Pl. VII, fig. 1 *a*)[2] and Asiatic.

The outline of the *temporal fossa* of course varies with the height of the dome. The antero-posterior extent, in relation to the vertical height, increasing progressively in different species, as stated by Falconer; in other words, the relative differences between the two measurements become less as the crown decreases. Consequently there must be wide differences in the outline of the temporal fossæ of the Mammoth and *E. meridionalis*. In *E. Namadicus* the contour is like that of the latter, the two measurements being nearly equal, whilst that of the Mammoth is rather peculiar (Pl. VII, fig. 1) as compared with other Elephants, being narrower and converging more to an apex at its upper and posterior angle. This feature is observed in other crania besides the above, but is not quite so pronounced,[3] which inclines me to believe that the compression of the occiput after death has exaggerated the character in the Ilford skull.

The *occipital* of the Mammoth (Pl. VI) is very large, and although the bosses on either side and deep centre for the ligament are not pronounced in the Ilford specimen, owing, doubtless in part, to injury and pressure, both are well shown in the Brussels skull, the hollow forming a pit large enough to hold the clenched fist. No doubt these characters were subject to variations, as observed in crania of the recent species.[4]

The *parallelism of the molars* in either jaw (Pl. VII, fig. 1 *a*), as compared with that in the living Elephants, was considered to be diagnostic of the Mammoth by Cuvier, but as Falconer truly observes, the character is not constant. The latter moreover states that they invariably converge in young and old of *E. meridionalis*:[5] indeed such is the case, more or less, in all members of the genus.

Little appears to be known of the *basal aspect* of the skull of the Mammoth in consequence, most probably, of the imperfect condition of the parts in the majority of specimens. In the Ilford skull the supports are in the way, irrespective of mutilations; the artist, however, has managed to afford a truthful representation of the chief parts in Pl. VII, fig. 1 *a*. As before stated, the alveolus of the right tusk has been restored in the drawing from that of the opposite side, and the left zygoma is also made up from the left, which is entire; there are besides restorations of the vault in places, but taken

[1] Op. cit., p. 125.

[2] This is the only part in my friend Mr. Griesbach's otherwise excellent illustration that is not quite true to nature. The outline of the arcade should have been more oval.

[3] Compare the above with pl. viii, fig. 1, and pl. xiv, fig. 2, of the 'Ossemens Fossiles,' which are indistinguishable in the contour of the temporal fossa from that of the cast in the Museum of the Royal College of Surgeons.

[4] 'Ossemens Fossiles,' pl. viii, fig. 1.

[5] 'Pal. Mem.,' vol. ii, p. 127.

generally, however, the skull is tolerably entire, and is unique as far as the British Islands are concerned.

The following admeasurements of crania of the Mammoth are compared with the recent species. Unfortunately no accurate data of the kind in connection with *E. meridionalis* have been, as far as I know, published, although there are magnificent skulls in the Museum of Florence.

	Ilford Cranium,[1] British Museum, Pl. VI, fig. 1. (*E. primigenius*).	Brussels Cranium,[2] cast in Mus. Roy. Col. Surg. of Eng. (*E. primigenius*).	Siberian. Oss. Fossil.,[3] vol. ii, 208, pl. 14, 2 (*E. primigenius*).	Siberian. Oss. Fossil.,[4] pl. 8, fig. 1, and 'Phil. Trs.,' vol. xi, pl. i (*E. primigenius*).	Siberian. Oss. Fossil., pl. xvii[5] (Adam's skeleton), (*E. primigenius*).	Volga Cranium.[6] Oss. Fossil., pl. 15, fig. 7 (*E. primigenius*).	India.[6] British Museum, presented by Corse (*E. Asiaticus*).	Ceylon[7]. 2656, Mus. Roy. Coll. Surgeons, England (*E. Asiaticus*).	African.[8] 2845 B, Mus. Roy. Coll. Surgeons, England (*E. Africanus*).
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
From the vertex to the premaxillaries	49½	41	56½	46½	51	47¼	42	44	24½
From the vertex to the nasals	16½	21	23½	...	...	19½	16	23	10
Breadth at the post-orbital processes	25½	28	...	...	...	27¾	27	25	21
Greatest breadth of the cranium ...	24	24	...	34¼	...	...	34	30	22
Space between the glenoid fossæ ...	16	12½	...	..	...	...	16	13½	10½
From the occipital to the premaxillaries	36	33	37	...	37½	...	34	35	27½
From the occipital condyles to the vertex	19	21	...	26¼	30¼	...	22	22	16½

It is important, since bones and teeth of *E. meridionalis* and *E. antiquus* were constantly confounded with those of the Mammoth, until Falconer established the presence of three distinct species of Elephants among the materials in British collections,

[1] This cranium represents an aged Elephant with the ultimate true molars nearly one half invaded: from the size of the tusks, which are each 8 feet 8 inches from the alveolar border to the apex, and 26 inches in their greatest girth, it was no doubt a male.

[2] The teeth in wear are the second true molars, which are more than half detrited. The individual was, therefore, full grown, but as the tusks are slender it may possibly have been a female.

[3] The tooth in this jaw has all the appearance, and Cuvier's description points to it, of being the last true molar, well worn. The size of the alveoli of the tusks indicates an old bull Elephant.

[4] Undoubtedly the last molar was in use in this skull.

[5] I am not aware of any record of the exact state of the dentition of this famous specimen, but unquestionably the last of the series must have been in use.

[6] One of the largest specimens of skulls of the Asiatic Elephant, belonging to the long-tusked or Dauntelle variety. It is referred to by Corse, 'Phil. Trans.,' 1798, p. 221, and may be the same cranium shown in pl. 18, fig. 4, of 'Ossemens Fossiles.' The tusk in the above is 46 inches along the convex side, and its maximum girth is 14 inches. The last true molar is in wear.

[7] The second true molar is more than half detrited, and the last is about one third worn. Tusks large.

[8] The first true molar is invaded in this skull. Tusks wanting.

to fully realise the differences between them. As regards the skull of *E. meridionalis* generally, he observes "that the cranium differs more from that of the Mammoth than does the latter from the existing Indian Elephant." The Italian form in this respect greatly resembles the cranium of *E. Hysudricus* from the Sewalik Hills, and is intermediate between it and the African Elephant, although widely different from both.[1] Unfortunately the skull of *E. antiquus* is not sufficiently known to admit of forming a like comparison ; the distinctions, however, as far as they extend, fully substantiate the diagnosis established by Falconer from the molars.

It is therefore in the *narrow summit, narrow temporal fossa*, and *inordinate long incisive sheaths*, that the Mammoth skull is chiefly distinguished from that of other species. The closest ally at present known is unquestionably the Asiatic Elephant.

2. MANDIBLE.

The mandible is usually found in a better state of preservation than any other portion of the skull. It shows much variability in character and dimensions irrespective of age, and bears out the same appearances observable in the teeth and other elements of the skeleton. But the discrepancies in the sizes of individuals and variations in skeletal characters are likely results in an animal which enjoyed such a very extensive distribution in space ; the only wonder is that it maintained its specific distinctions so well. As with the recent species, no doubt certain regions presented more favorable conditions for the growth of the Mammoth, whereby local varieties and races, distinguishable by certain appearances, were developed ; for it is well known to elephant hunters and elephant catchers that a herd is a family.[2]

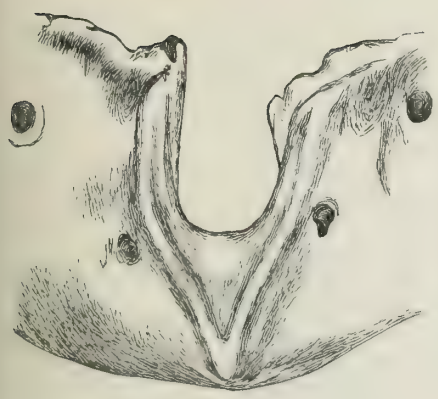
The *round* and *truncated chin* of the Mammoth has been advanced as a very distinctive character, and in the majority of instances, especially the typical specimens from the boreal regions of Europe, Asia, and America, both points are very apparent. In such jaws the rami meet at the symphysis by more rounded curves than ordinarily obtain in other species, but the rule is by no means invariable, and must not be considered absolutely diagnostic, inasmuch as the jaw in many instances is indistinguishable from that of the Asiatic, especially in mandibles of the latter containing the first and second true molars. In aged Elephants the horizontal rami becomes attenuated by absorption of the walls of the dental cavities. These discrepancies in the contour of the mental region are well shown in the following woodcuts, which represent the mandibles of full-grown Mammoths from various localities.

In *E. antiquus* the rounding was also pronounced, as is well seen in Woodcut, fig. 13, and indeed the same, to a great extent, characterises the chin of *E. Namadicus ;* however, although there are individual instances, such as the superb specimen of the mandible of *E. meridionalis*, in the Woodwardian Museum, Cambridge, from the Forest Bed, where

[1] Op. cit., vii, p. 126.

[2] Sanderson, 'Thirteen Years among the Wild Beasts of India.'

FIG. 4.

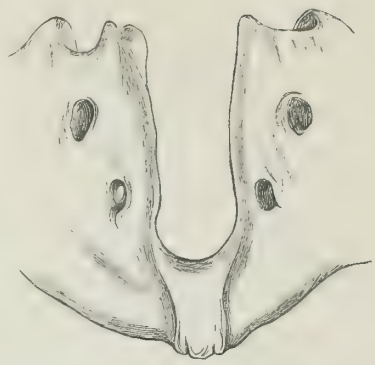


E. primigenius, London. (British Museum Collection, No. 38,136.)

FIG. 5.

E. primigenius, Arctic America. (British Museum Collection, No. 61 *a*.)

FIG. 6.

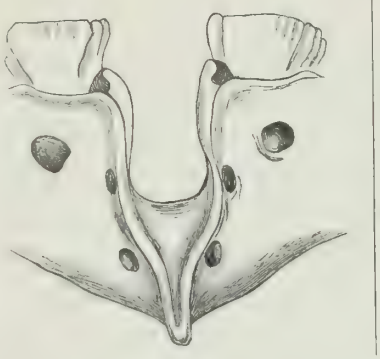


E. primigenius, Harbour, Holyhead. (British Museum Collection,No. 38,567.)

FIG. 7.

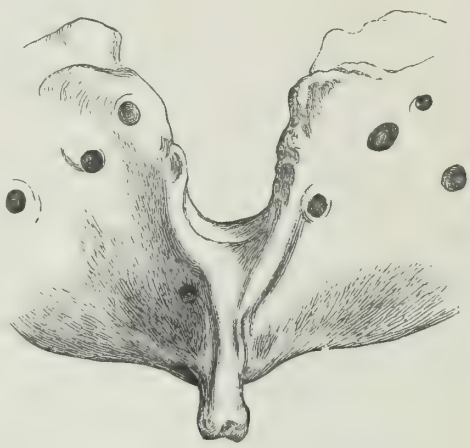
E. primigenius, Dogger Bank. (British Museum Collection, No. 46,215.)

FIG. 8.



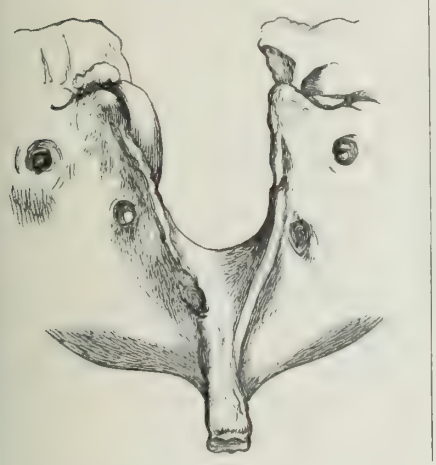
E. primigenius, Ilford. (British Museum Collection, No. 44,974.)

FIG. 9.



E. primigenius, Dogger Bank. (British Museum Collection, No. 46,197.)

FIG. 10.

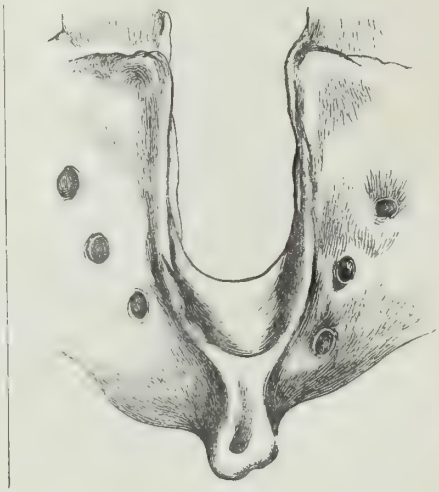


E. primigenius, Ilford. (British Museum Collection, No. $\frac{c}{48}$.)

FIG. 11.

E. primigenius, Ilford. (British Museum Collection, No. $\frac{c}{45}$.)

FIG. 12.



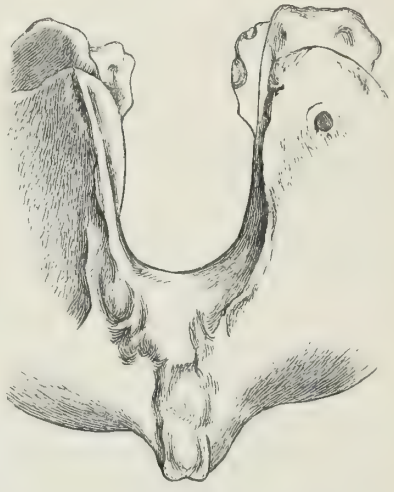
E. primigenius, Ilford. (British Museum Collection, No. $\frac{c}{46}$.)

the chin is nearly as rounded as in Woodcut, fig. 4, such is by no means the case in the jaws from the Val d'Arno at Florence and the cast in the British Museum, shown in Woodcut, fig. 14.

Fig. 13.

E. antiquus, British.
(Collection of Geological Society of London.)

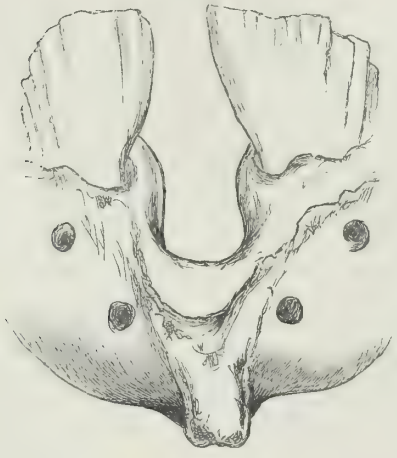
Fig. 14.



E. meridionalis, Val d'Arno.
(British Museum Collection, No. 37,334.)

In the two recent species there are good distinctions to be made on this character, the chin of the Asiatic Elephant presenting the usual aspect of that of the Mammoth, subject to the same variations, whereas of several mandibles of the African I have never seen the broad round chin of Woodcut, fig. 15. The more pointed mental region of the mandible of the African agrees with that of *E. meridionalis*, to which species there is a closer relationship in other skeletal elements than with the Mammoth.

Fig. 15.

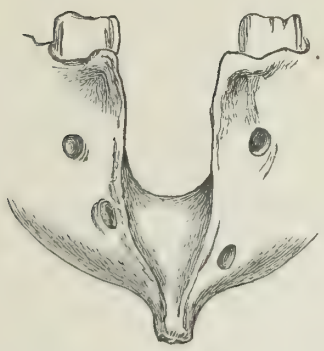


E. Asiaticus. (Collection
of Royal College of Surgeons, No. 2656 *a*.)

Fig. 16.

E. Asiaticus. (Collection
of Royal College of Surgeons, No. 2674.)

Fig. 17.



E. Asiaticus. (Collection of Royal College of Surgeons, No. 2675.)

Fig. 18.

E. Africanus. Collection of Royal College of Surgeons, No. 2847.)

The so-called truncated chin which Falconer and others have referred to as diagnostic of the Mammoth, will be also seen from the foregoing cuts and those on p. 135 to be by no means regular, there being much variability, from an obsolete rostrum (figs. 4 and 7) to the long beak of Woodcut, fig. 11, which is fully three inches in length, and grooved; indeed, the beak is variable in the recent species likewise; and, like the angle of convergence of the rami at the symphysis, it is not a reliable character in any one of the living or extinct Elephants hitherto described.

Horizontal and ascending ramus.—The relative and absolute lengths of the horizontal and ascending rami furnish some important comparisons in the different species. The Mammoth and Asiatic Elephant display close affinities in these respects; *E. meridionalis* and *E. Africanus* are closely associated; and *E. antiquus* and *E. Namadicus* are, as far as the specimens I have examined extend, also come together, the two latter being nearer to the two former than to the Meridional and African forms, where the disparities in relative lengths between the horizontal and ascending rami are far greater than in the other four. Again, there are less differences between the length of the horizontal ramus and maximum width of the ascending ramus in the Mammoth, and also in the Asiatic (but to a smaller extent in the latter), than in *E. antiquus*, and notably *E. meridionalis* and *E. Africanus*, as will appear presently.

In point of depth of the horizontal ramus and consequent length of diasteme, both attain their maximum in the middle period of life, and decline in very old age, when the teeth grow up and cover a space between them and the alveoli, which become absorbed, so that the mandible is then not nearly so thick and deep as in younger individuals. This is well seen in Pl. VIII, fig. 3, which represents a very old individual, the last true molar being more than half worn away, whilst the surrounding socket as shown, p. 122, seems too large for the teeth.

Symphysial gutter and its foramina.—The wide spout or gutter of the mandible of the Mammoth is, as far as I am aware, unequalled by that of any known species. There are

usually two good-sized internal foramina, which, however, may be wanting. These are also present in the Asiatic, but are usually smaller and more numerous, whereas in many mandibles of the African Elephant I have examined not a trace of these canals is seen. They seem to be present in both *E. antiquus* and *E. meridionalis*.

The length of the symphysis being dependent on the prominence or otherwise of the chin, it will usually be longer in the long-beaked species than ordinarily in the Mammoth and Asiatic Elephant. But the great width of the gutter, although very general, is not an invariable character. It is well shown by the Woodcuts at p. 135, an exceptional instance being seen in the jaw (fig. 6) dredged in Holyhead Harbour, as compared with fig. 7 and other mandibles.

The *diasteme* is nearly vertical in the majority of mandibles of the adult Mammoth that have come under my notice, but there is no uniformity in this character, and its height increases from youth to mature age. It is high in *E. antiquus*, *E. Namadicus*, and *E. Asiaticus*, and more depressed in *E. Africanus*, *E. planifrons*, and *E. meridionalis*.[1] In the last named "it slips gradually into the beak, making a longer symphysis and spout."[2] The diasteme appears, therefore, like the rostrum, to be subject to variation in the degree of inclination in the adult Mammoth, but upon the whole it is more erect in it than in either of the recent, and in any jaws of extinct species hitherto recorded. The following woodcuts represent this character in various specimens and species.

Fig. 19.

E. primigenius, Arctic. (British Museum Collection, No. 61 *a*.)

Fig. 20.

E. primigenius, Harbour Holyhead. (British Museum Collection, No. 38,567.)

Fig. 21.

E. primigenius, Dogger Bank. (British Museum Collection, No. 46,215.)

[1] The dip of the diasteme in this species, although low as compared with the Mammoth, is not always so, as Woodcut fig. 28 shows, while a still higher angle is displayed in the ramus from the Forest Bed lately mentioned, to which further reference will be made in my Monograph on *E. meridionalis*.

[2] 'Pal. Mem.,' vol. ii, p. 127.

Fig. 22.

E. primigenius, Ilford. (British Museum Collection, No. 44,979 and $\frac{c}{49}$.) Brady Cat.

Fig. 23.

E. primigenius, Dogger Bank. (British Museum Collection, No. 46,197.)

Fig. 24.

E. primigenius, Ilford. (British Museum Collection, No. $\frac{c}{48}$.)

Fig. 25.

E. primigenius, Ilford. (British Museum Collection, No. $\frac{c}{45}$.)

Fig. 26.

E. primigenius, Ilford. (British Museum Collection, No, $\frac{c}{46}$.)

Fig. 27.

E. antiquus, British. (Collection of the Geological Society of London.)

Fig. 28.

E. meridionalis, Val d'Arno. (British Museum Collection, No. 37,334.)

Fig. 29.

E. Asiaticus. (Collection of Royal College of Surgeons, No. 2656 *a*.)

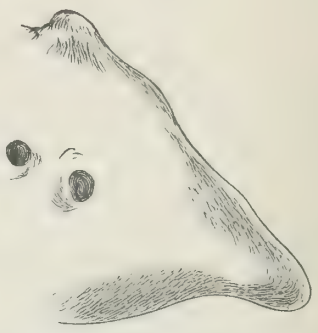
Fig. 30.

E. Asiaticus. (Collection of Royal College of Surgeons, No. 2675.)

Fig. 31.

E. Africanus. (Collection of Royal College of Surgeons, No. 2847.)

Fig. 32.



E. Asiaticus. (Collection of Royal College of Surgeons, No. 2674.)

Expansion of the mandible.—The mandible of the Mammoth expands more at the angles and between the condyles than in either of the recent species. The ascending rami converge more at their summits in the Asiatic than in the Mammoth and *E. meridionalis*. I have not seen a mandible of *E. antiquus* with the condyles preserved, but otherwise this character is like that of the Mammoth as regards the greater relative breadth of the jaw at the middle and base of the ascending rami. This expansion at all stages of growth is marked in these extinct forms, as compared with the Asiatic Elephant; and shows a relatively broader jaw, at all events as far as the Mammoth is concerned. There is likewise a relatively greater expansion of the mandible of *E. meridionalis* than in the Asiatic, especially about the angle of the ascending rami.

Posterior border.—The posterior border of the ascending ramus of the Mammoth and Asiatic are much alike, being more rounded than in that of the other British fossil Elephants and the African species, demonstrating the contrast just referred to in relation to the length of the horizonal ramus.

The inferior margin of the lower jaw of *E. meridionalis* shows "a well-marked concave arc," which I have not seen in any ramus of the Mammoth.

The dental canal.—In both the Mammoth and Asiatic Elephant the posterior and inner border of the ascending ramus usually descends from the inner side of the condyle, and is lost after passing the rim of the dental canal, whilst it is still traceable in the African to the angle, at all events in many specimens of the latter I have been enabled to follow its course to that point which does not seem possible in the jaws of the other two species.

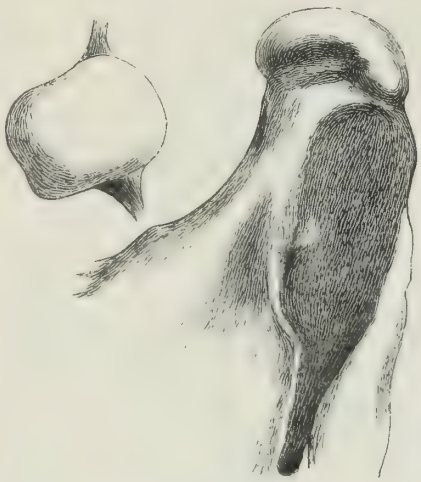
The canal looks directly upwards in the Mammoth and Asiatic (Woodcuts, figs. 33, 34, 35, and 37). This I have noticed is almost constant; indeed, I have only seen the exception (fig. 35), which is recorded at p. 103, where the opening is low down and directed backwards. In *E. meridionalis*, *E. Africanus*, and, as far as a single imperfect specimen (Woodcut, fig. 36) extends, in *E. antiquus*, the opening is also directed *inwards*.

The crotchet on the brim, so pronounced in the Asiatic (Woodcut, fig. 37), is by no means as prominent in the Mammoth, *E. antiquus*, and *E. Africanus;* indeed, it is seemingly sometimes scarcely pronounced and almost obsolete in the Mammoth, as shown in figs. 33, 34, and 35, nor is it very prominent in *E. Africanus* (fig. 38).

Fig. 33.

E. primigenius, Ilford. (British Museum Collection, No. 44979, $\frac{c}{49}$.

Fig. 34.



E. primigenius, Ilford. (British Museum Collection, No. $\frac{c}{45}$.)

Fig. 35.

E. primigenius, Ilford. (British Museum Collection, No. $\frac{c}{46}$.)

Fig. 36.

E. antiquus. (Museum of the Geological Society of London.)

Fig. 37.

E. Asiaticus. (Collection of Royal College of Surgeons, No. 2675.)

Fig. 38.

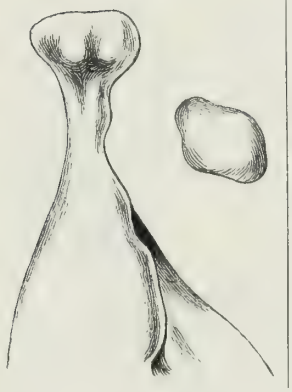
E. Africanus. (Collection of Royal College of Surgeons, No. 2847.)

The contour of the condyle is subject to individual differences even in the same jaw, as shown in Woodcut, fig. 39; but usually the outlines of the head are relatively broader in the Mammoth and Asiatic Elephant than in the African. The affinities between the two former are no doubt close, as appears from Woodcuts, figs. 34 and 37, whilst that of

the African (fig. 41) shows a greater disposition to constriction at the middle—a character seemingly present also in *E. meridionalis* (fig. 40). I must admit, however, that the condyle does not seem to me a satisfactory means of diagnosis.

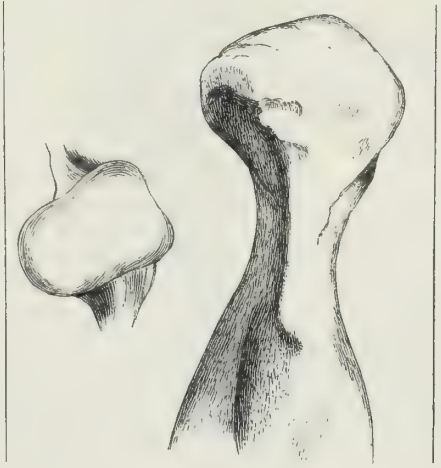
The *posterior aspect of the neck of the mandible* is seemingly alike, with very little variation, in both the Mammoth and the Asiatic Elephant, being relatively narrower than obtains in the Meridional and African species, which again present close affinities. This will be more or less apparent from the following Woodcuts, figs. 39, 40, and 41.

Fig. 39.



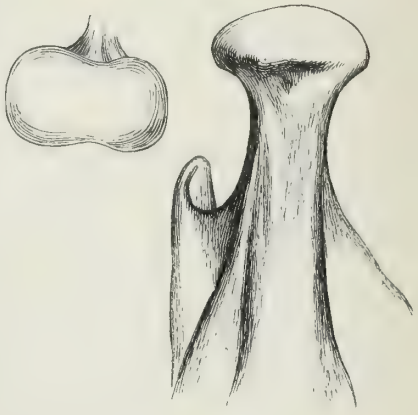
E. primigenius, Ilford. (British Museum Collection, No. $\frac{6}{49}$.)

Fig. 40.



E. meridionalis, Val d'Arno. (British Museum Collection, No. 37,339.)

Fig. 41.



E. Africanus. (Collection of Royal College of Surgeons, No. 2846.)

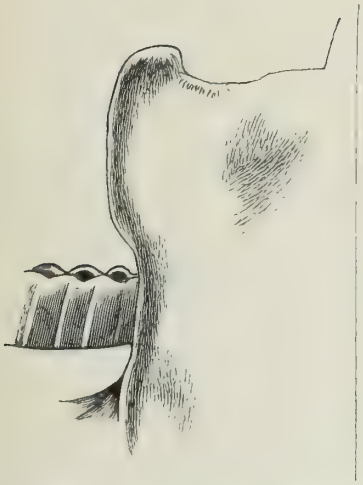
Coronoid.—The coronoid in the Mammoth does not generally rise within two inches of the upper surface of the condyle. Its anterior border is sometimes straight, sometimes concave, generally slightly concave with thickening of the apex. In the Asiatic it is nearly level with the summit of the condyle, the anterior border presenting a similar variability to that of the Mammoth, whereas it is usually concave in the African, whose condyle is nearly level with the apex of the coronoid. The characters of the anterior border are, however, so subject to variation, that little reliance can be placed on it as distinctive of any one species.

The beetling of the anterior and upper portion of the coronoid has been considered a character of the two recent species; but this is by no means the case, as the contour is constantly varying in specimens, and is very variable also in the jaw of the Mammoth, as also seen in the accompanying Woodcuts, figs. 42, 43, 44, 45, and 46.

Foramina.—The external mental foramina are, as a rule, closer to the free margin of the diasteme in the Asiatic Elephant and Mammoth than in the African, and, perhaps, the *E. meridionalis* and *E. antiquus;* but that there are exceptional instances, and that the condition

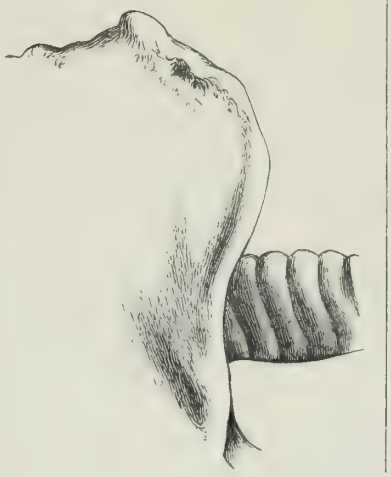
[1] Falconer, op. cit., vol. ii, p. 128.

Fig. 42.



E. primigenius, Ilford. (British Museum Collection, No. $\frac{c}{47}$.)

Fig. 43.



E. primigenius, Ilford. (British Museum Collection, No. $\frac{c}{49}$.)

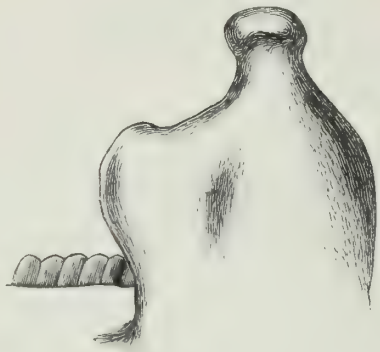
Fig. 44.

E. antiquus, British. (Collection of Geological Society of London.)

Fig. 45.

E. Asiaticus. (Collection of Royal College of Surgeons, No. 2664.)

Fig. 46.



E. Asiaticus. (Collection of Royal College of Surgeons, No. 2674.)

constantly varies, as will at once be very apparent from the woodcuts from p. 135 to p. 140; indeed, as a means of diagnosis the numbers and positions of the mental foramina are not reliable in any one species, recent or extinct.

The following table gives the measurements of mandibles of the three extinct British species and the jaw of the Asiatic Elephant, with the view of showing the comparisons of the more important parts in individuals of about the same relative ages.

	No. $\frac{C}{49}$ B. M., Ilford. Very old, only 16 ridges of last molar in use, Pl. VIII, fig. 3 (*E. primigenius*).	No. 61*a*, B. M.,[1] Eschscholtz Bay, Arctic America. Last molar more than half detrited (*E. primigenius*). Woodcut, fig. 5.	Geol. Soc. Mus., Burlington House, locality unknown.[2] Last true molar commencing wear, portion of second in use, Faun. Ant. Sival., p. 13 A and B, fig. 4 (*E. antiquus*). Woodcut, fig. 13.	Woodwardian Museum, Cambridge, "Forest Bed," Norfolk Coast. Last molars in full wear (*E. meridionalis*).[3]	No. 37,334, B. M., cast, Val D'Arno. Same state of dentition as in mandible of *E. antiquus* (*E. meridionalis*). Woodcut, fig. 14.	Mandible of Corse's specimen (B. M.) of the cranium, referred to at p. 133, with two last molars in use (Dauntelle variety of *E. Asiaticus*).
Extreme length of the jaw	22	25	20	22	29	29
Maximum thickness at front of the ascending ramus	5·7	6·5	7·	7·5	7·	6·
Height at the summit of the diasteme	5·8	8·	10·	9·	9·	$8\frac{1}{2}$
Greatest expansion of rami at their outer borders	21·	Lost	24·5	23·	22	22
Length and breadth of ultimate molar	8·2 × 3·2	8· × 3·	12· × 3·1[3]	...	8· × 3·5[4]	8· × 3·[5]
Space between molars in front	3·5	3·5	3·2	...	4·4	3·5
„ „ middle	4·	...	3·6	...	3·	...
„ „ behind	10	7·5	...	...	...	8·5
From tip of rostrum to posterior border of symphysial gutter	7·5	5·	5·2	...	7·	8·5[6]
Greatest width of gutter in front	2·5	2·8	3·6	3·5	4·	2·
Height of ascending ramus to summit of condyle	15·2	15·5	16·3[7]	...	17	19
Breadth of ascending ramus	12·	Lost	11·5	...	9·5	11·5
Length of horizontal ramus from diasteme to anterior border of coranoid	8·	8·	8·8	8·	11·	9·5

The general characters which distinguish the mandible of the Mammoth from that of its extinct co-species may be epitomised as follows:—1. The chin is usually broad. 2. The rostrum poorly developed. 3. The diasteme is nearly erect, very generally high. 4. The symphysial gutter is wide. 5. The posterior border of the ascending ramus is rounded. 6. The sides of the condyle are only slightly compressed. 7. Dental canal opens upwards. 8. There is less difference in length between the horizontal and ascending rami. 9. The posterior surface of the neck of the condyle is narrow.

In all these characters it approaches closer to the Asiatic Elephant than to any other species hitherto recorded. The Asiatic has a relatively less expansion of the rami and a

[1] Referred to p. 123.

[2] Referred to Monograph on *E. antiquus*, p. 54.

[3], [4], [5] Last molars hidden in jaws; the lengths, therefore, are from the parts exposed.

[6] Rostrum is very long, four inches in length.

[7] The condyles are wanting, therefore the length is from the *neck*.

[8] Condyles and neck lost. I have only given a few measurements of this very interesting mandible, as I propose to describe and figure it in my next Monograph.

more pronounced crotchet or process on the margin of the dental canal, but otherwise the variability to which the jaw of the Mammoth is subject seemingly goes nearly hand in hand with the variations in the mandible of the Asiatic Elephant.

3. SHOULDER GIRDLE.[1]

Scapula.—Cuvier was the first to record the points of resemblance between the scapula of the Mammoth and that of the Asiatic Elephant;[2] and Nesti makes a similar statement with reference to *E. meridionalis*.[3]

Unfortunately the shoulder-blades of *E. antiquus* have not been described, whilst the scapula in the so-called Adams's skeleton in St. Petersburg has been shown by Cuvier to be wrongly put together; indeed, it would appear that this is the case with various other portions of that skeleton, which has been constructed from bones of several individuals. The neck of the scapula in the Mammoth is broader and the glenoid cavity relatively wider than in the recent species, as pointed out by Cuvier.

According to De Blainville the recurved process, or crotchet, is less curved than in the Asiatic, and the acromion is nearer to the articular surface, whilst the suprascapular border is more arched than in the latter species.[4]

With reference to the contour of the glenoid cavity, Busk has observed that it is broad and oblong in the African, whilst there is a constriction of the sides in the Asiatic and Mammoth.[5]

The almost entire, and the only well-preserved specimen of the scapula I have seen from British strata is shown in Pl. XV, fig. 1 *a*, *b*. I am informed by Mr. Davies that its integrity is owing entirely to the care bestowed, in its removal from the matrix, by the Rev. Nicholas Brady, M.A., son of Sir Antonio Brady, F.G.S., to whom science is indebted for the recovery of numerous other Pleistocene remains from the famous brickfields of Ilford. Only a small portion of the anterior border is wanting in the specimen. The above-mentioned characters are well shown in Pl. XV, fig. 1 *a*, *b*, whilst the distinctions between the scapulæ of the two recent species and that of the Mammoth will appear from Pl. XV, figs. 2 and 3.

The spine (fig. 1 *a*) rises higher above the plain of the scapula in the Mammoth than is apparently the case in either of the recent species.

[1] The vertebral column should properly follow the preceding details, but entire specimens of its elements are not easily procured. I hope, however, to be enabled to obtain sufficient data to enable me to point out their characters in my next memoir. In the meantime I shall proceed to the consideration of the anterior extremity of the Mammoth.

[2] 'Ossem. Foss.,' vol. ii, p. 216.

[3] 'Fossili del Val d'Arno,' fig. 6.

[4] 'Ostéographie des Mamm.,' p. 171.

[5] 'Trans. Zool. Soc. Lond.,' vol. vi, p. 244.

In the African (Pl. XV, fig. 3) the anterior border is more rounded than in the Asiatic (fig. 2), and apparently in the Mammoth; and the crotchet is more bent downwards than in either of them. The antero-posterior length of the neck is relatively smaller in the African, but it is apparently broader in the Mammoth than in the Asiatic Elephant. The position of the crotchet would seem to stand in its relation to the glenoid cavity in the following order:—It is nearest in the African, further up in the Asiatic, and slightly more so in the Mammoth.

The glenoid is clearly, as shown in figs. 2 *a* and 3 *a*, broadly distinctive in the African as compared with Asiatic and the Mammoth (fig. 1 *a*) and even *E. meridionalis*.[1]

The supra-scapular border is seemingly more arched in the Mammoth than in the Asiatic, and is more even in the African than in either of them.

The following are the measurements of the three scapulæ in question:

	Plate XV, Fig. 1. No. $\frac{C}{119}$ Brady Collection, B.M., Ilford.	Plate XV, Fig. 2. *E. Asiaticus*, 2744d,[2] Mus. Roy. Coll. Surg. Eng.	Plate XV, Fig. 3. *E. Africanus*, 708b, B.M.[3]
	Inches.	Inches.	Inches.
Extreme length	32	34	27·5
Extreme breadth	37	30·5	26
Height of the spine	8	8·5	5
Length of the spine	28	31	29·5
From coracoid to the tip of the acromion	6·2	4	4
Coracoid to the tip of the crotchet	15	13	10
Acromion to the upper and inner border of the recurved process	15·5	14·5	11·5
Acromion to the tip of the recurved process	11	10	9·5
Length of the anterior border	—	22	22
Length of the posterior border	22	19	13
Length of the supra-scapular border to the commencement of the spine	27·5	32	24
Dimensions of the glenoid cavity	6·8×4	7×4·2	6·8×3·8
Antero-posterior length of the neck	10	10	8

Besides the above there are several other fragments of shoulder-blades from the Ilford brick-earths in the Collection and in the Catalogue. For example, No. $\frac{C}{120}$ has a glenoid cavity of 6·5×3·9 inches; No. $\frac{C}{122}$, 6·8×3·3; No. $\frac{C}{123}$, 6·8×3·8. In Mr. Owles's Collection from the Dogger Bank, the glenoid cavity of No. 46,256 is 7.7×4·7, and No. 46,257 is 8·×5· inches.

[1] 'Ossemens Fossiles,' pl. xiii, fig. 5.

[2] This is the largest scapula of the Asiatic Elephant I have seen. The pelvis and humerus of the same individual is preserved in the Museum. I have referred to the latter in my Monograph on *E. antiquus*, p. 59.

[3] The second true molar is in wear in the skull of this individual, showing that it was an old Elephant.

PLATE VI.

Elephas primigenius.

Fig. 1. Reduced to about $\frac{1}{9}$ natural size, and fig. 1 *a* a much reduced drawing of the same cranium from Ilford, Essex, in the British Museum.

Figs. 2 and 2 *a*. Crown and profile of No. 44,734, British Museum, a right lower penultimate milk molar from Hutton Cave, in the Mendip Hills, Somersetshire. (Natural size.)

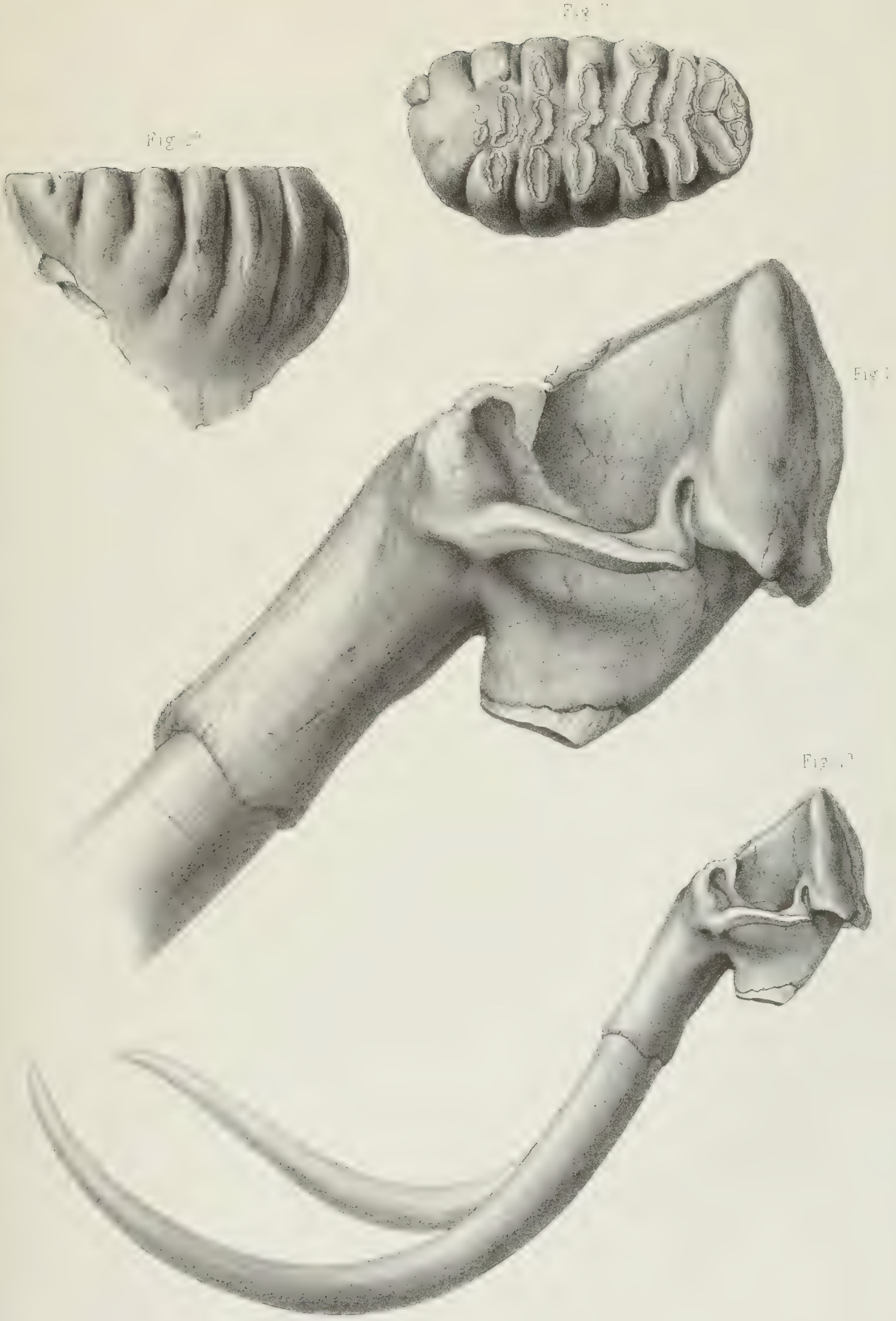


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PLATE VII.

Elephas primigenius.

Figs. 1 and 1 *a*. Frontal and basal aspects of the Ilford cranium, British Museum. ($\frac{1}{7}$ natural size.)

Fig 1a

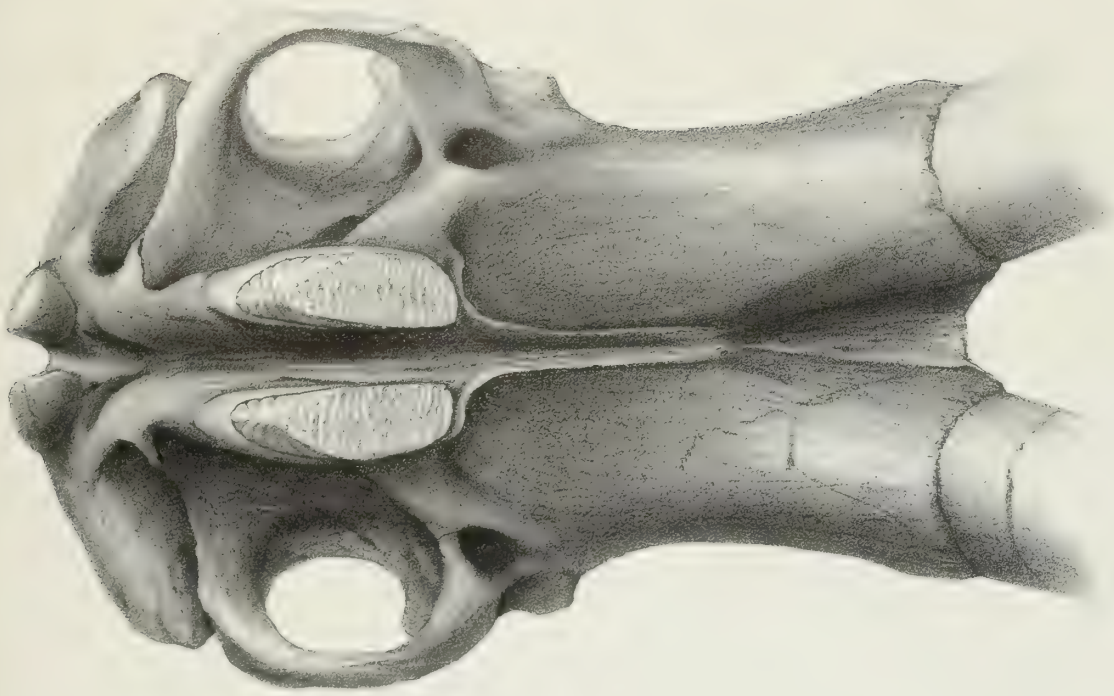

Fig. 1

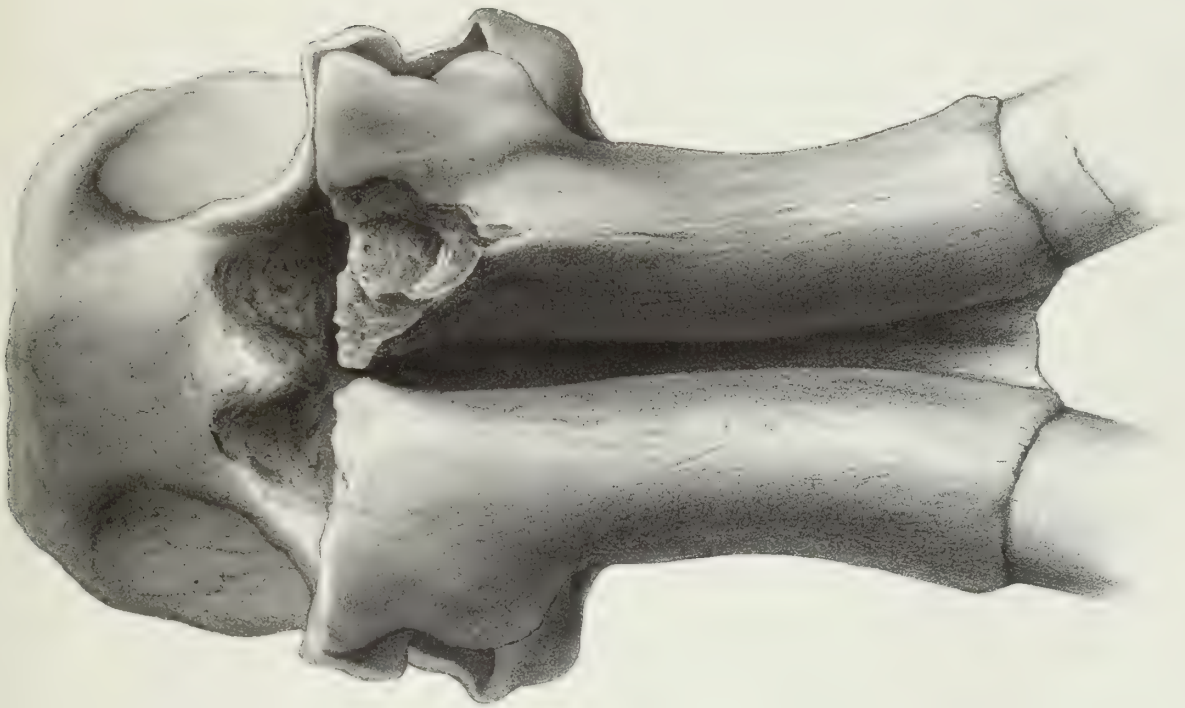

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PLATE VIII.

Elephas primigenius.

Fig. 1. Crown view of a mandible, No. c 41, Brady Collection, British Museum, showing the last milk molar, from Ilford, Essex. (About $\frac{1}{4}$ natural size.)

Fig. 2. Crown view of the mandible, No. c 43, Brady Collection, British Museum, containing the first or ante-penultimate true molars, from Ilford. (About $\frac{1}{4}$ natural size.)

Fig. 3. Crown view of the mandible, No. c 49, Brady Collection, British Museum, showing the last true molar, from Ilford. (About $\frac{1}{4}$ natural size.)

Figs. 4, 4 *a*, 4 *b*, and 4 *c*. Profile, crown, back, and basal views of an upper ante-penultimate milk molar, No. 4 of Professor Boyd Dawkins' Collection, from Wookey Hole Cave, Mendip Hills, Somersetshire. (Natural size.)

Figs. 5, 5 *a*, 5 *b*, and 5 *c*. Profile, crown, back, and basal views of lower ante-penultimate milk molar, No. 1 of Professor Boyd Dawkins' Collection, from Church Hole, Notts. (Natural size.)

Figs. 6, 6 *a*, and 6 *b*. Profile, crown, and back views of lower ante-penultimate milk molar, No. 2 of Professor Boyd Dawkins' Collection, from Wookey Hole. (Natural size.)

Figs. 7, 7 *a*, 7 *b*, and 7 *c*. Profile, crown, back, and basal views of upper ante-penultimate milk molar No. 3 of Professor Boyd Dawkins' Collection, from Robin Hood Cave, Creswell Crags, Derbyshire. (Natural size.)

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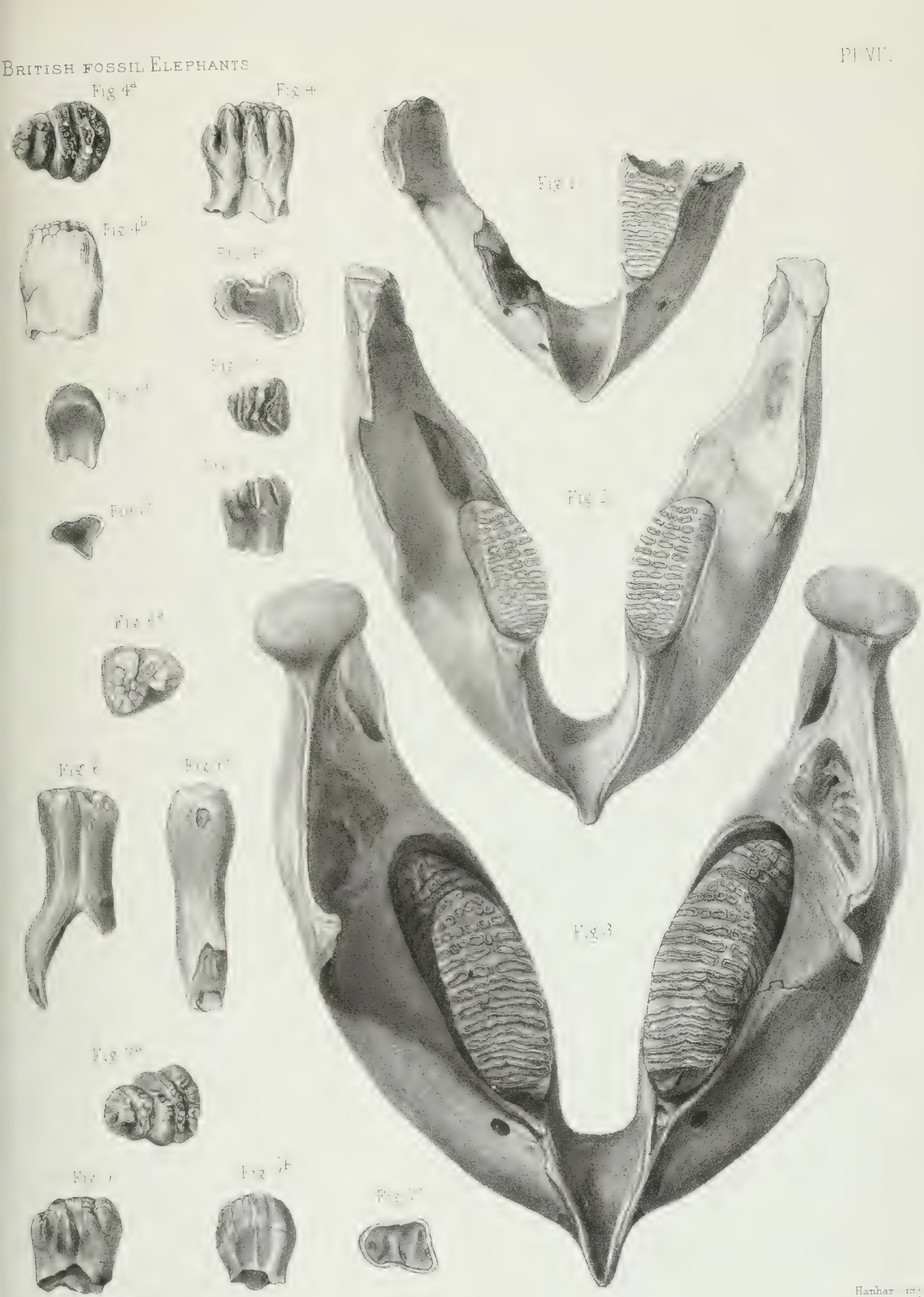


Hanhart imp

PLATE IX.

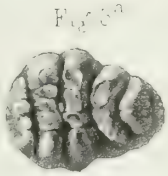
Elephas primigenius.

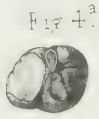
Figs. 1 and 1 *a*. Profile and crown of No. 46,147, British Museum, an upper penultimate true molar in the Owles's Collection, from the Dogger Bank, German Ocean. (Half natural size.)

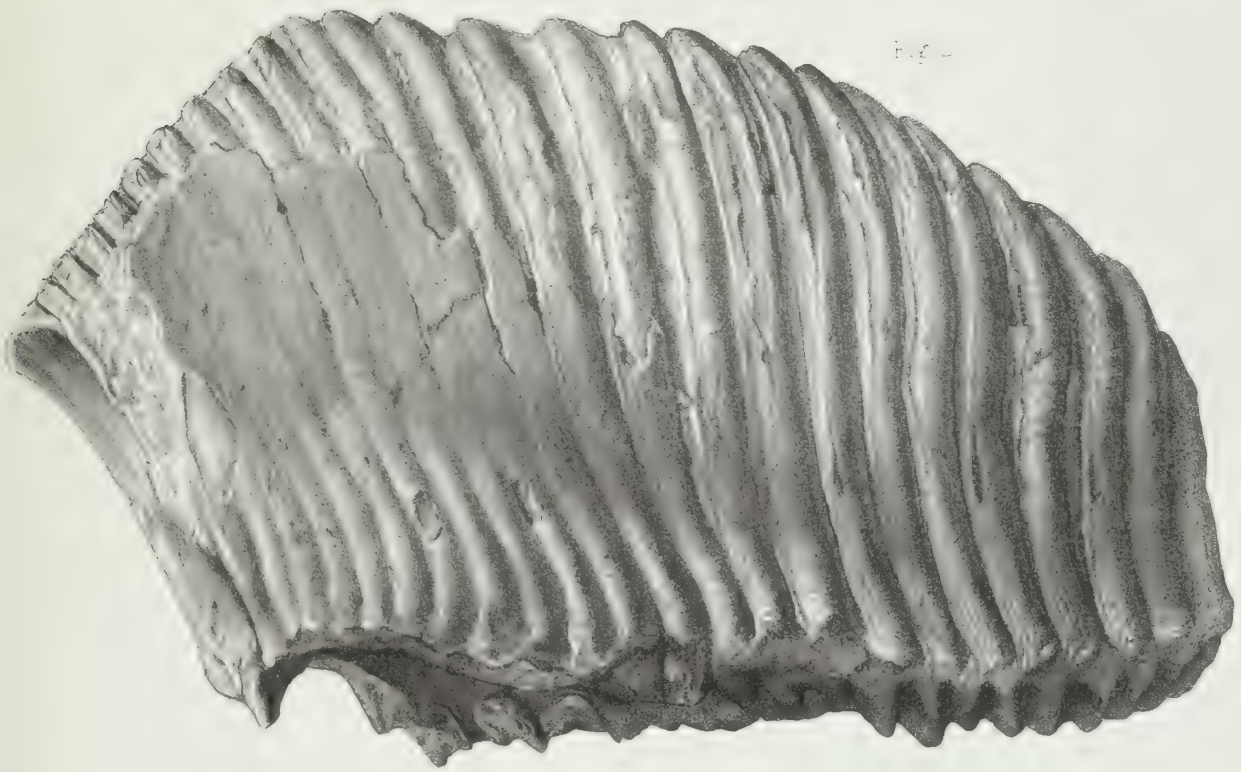
Fig. 2. Profile of No. 39,695, British Museum, a left upper last true molar, from Spalding, in Lincolnshire. (Half natural size.)

Figs. 3, 3 *a*, 3 *b*, and 3 *c*. Profile, crown, back, and basal views of the right (?) upper ante-penultimate milk molar, No. 1063 of the Kent's Cavern Collection, Torquay, Devonshire. (Natural size.)

Figs. 4, 4 *a*, and 4 *b*. Profile, crown, and back views of the *pre*-ante-penultimate milk molar (?), No. 5774 of the Kent's Cavern Collection, Torquay. (Natural size)







C.L. Griesbach, ad nat.

Hanhart imp.

PLATE X.

Elephas primigenius.

Figs. 1 and 1 *a*. Upper and profile views of mandible, No. 44,967, Brady Collection, British Museum, containing the penultimate milk molars, from Ilford, Essex. (Natural size.)

Fig. 2. Upper view of a fragment of a left ramus of a mandible, No. 21,311, British Museum, showing the alveoli of the ante- and the penultimate milk molars, from Ilford. (Half natural size.)

Fig. 3 and 3 *a*. Crown and profile views of a left upper penultimate milk molar, No. 46,422, British Museum, from Wookey Hole Cave, Mendip Hills, Somersetshire, (Natural size.)

Fig 3

Fig 1a

Hanhart

PLATE XI.

Elephas primigenius.

Fig. 1 and 1 *a*. Profile and crown views of a right lower last milk molar, No. 39,041, British Museum, from Bracklesham Bay, Sussex. (Natural size.)

Fig. 2. Crown view of a right upper first true molar, No. 46,211 of the Owles's Collection, British Museum, from the Dogger Bank, German Ocean. (Natural size.)

Fig 1a

Fig 1

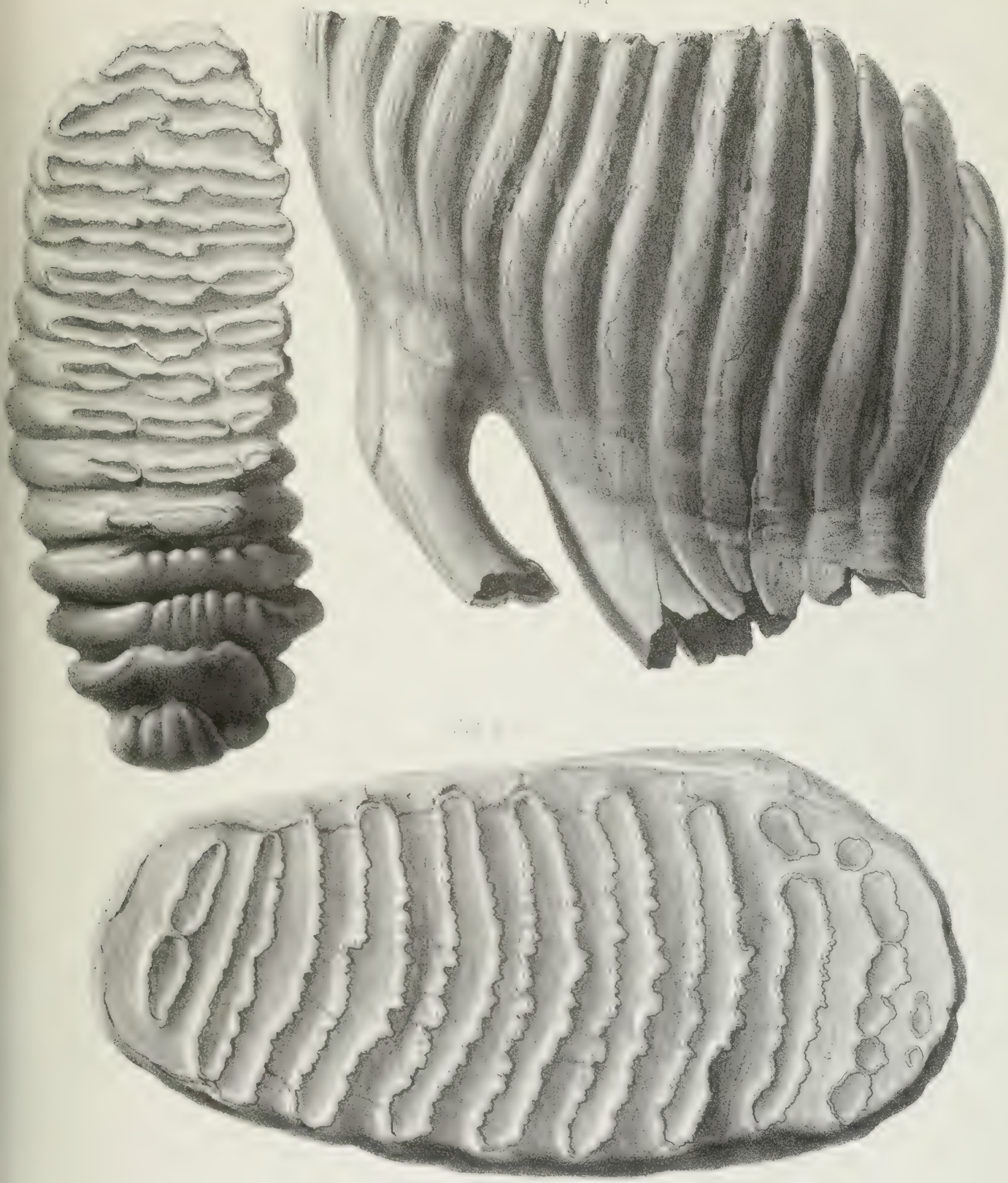


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PLATE XII.

Elephas primigenius, and E. antiquus.

Fig. 1. Crown view of a left lower second true molar of *E. primigenius*, in the Museum of Practical Geology, London, from Crayford, Kent. (Natural size.)

Fig. 2. Crown view of a right upper penultimate milk molar of *E. primigenius*, No. 5489 of the Kent's Cavern Collection, Torquay, Devonshire. (Natural size.)

Figs 3 and 3 *a*. Profile and crown views of a left upper ante-penultimate, and profile of a penultimate milk molar of *Elephas antiquus*, in the Museum of Practical Geology, from Ilford, Essex. (Natural size).

Fig. 3.

Fig. 3*

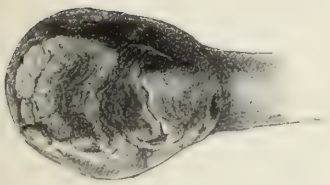


Fig. 2

Fig. 1.

Nat. size

Mintern Bros imp

R. Mintern del. et lith.

PLATE XIII.

Elephas primigenius.

Figs. 1 and 1 *a*. Profile and crown views of a left upper last true molar, No. 35 of the Woodwardian Museum, Cambridge, from Kirby Park, Melton Mowbray, Leicestershire. (Natural size.)

Fig. 2. Profile view of a lower penultimate milk molar, in the British Museum, from Kent's Cavern, Torquay, Devonshire. (Natural size.)

Fig. 1

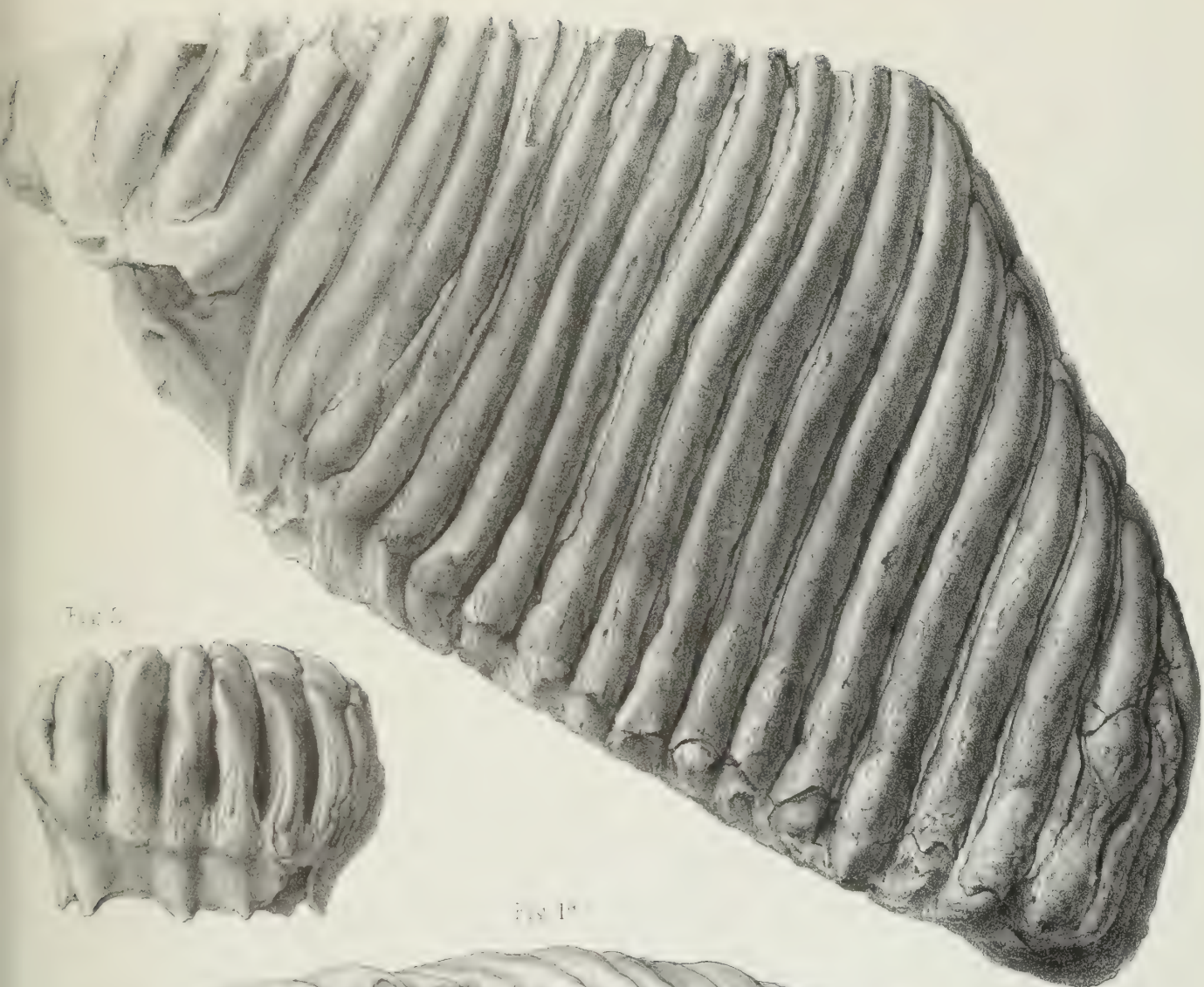
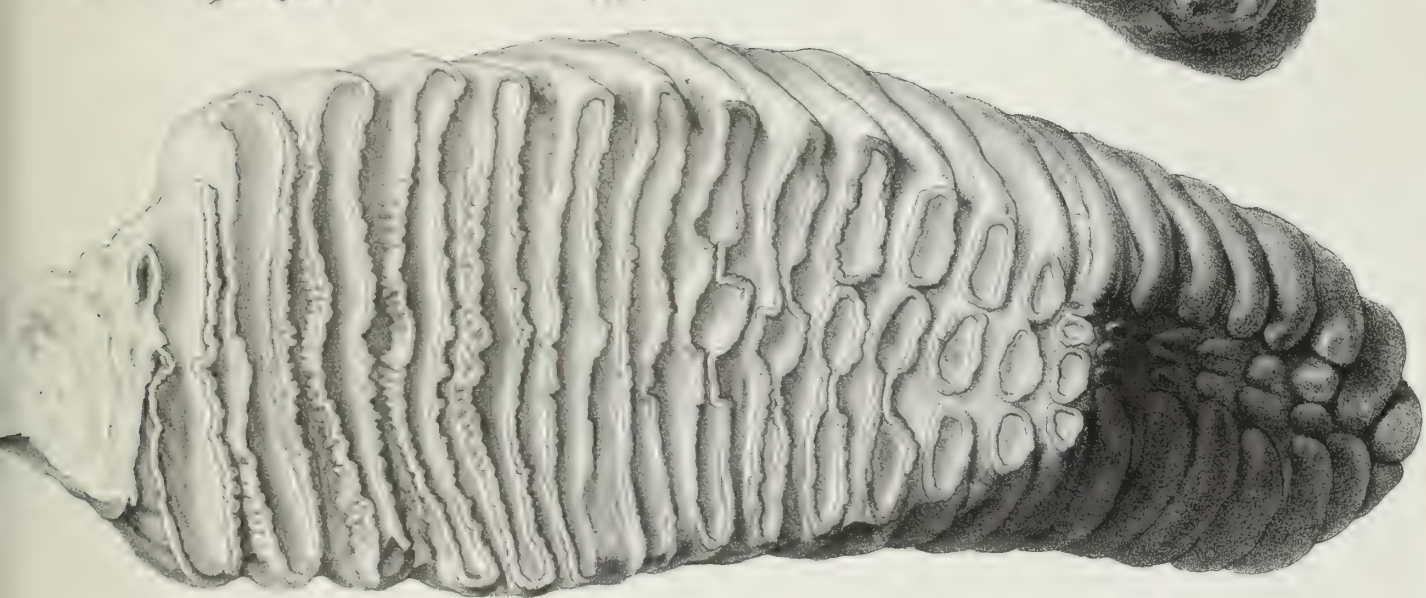


Fig. 2.

Fig. 3.



C. L. Griesbach lith. Hanhart imp

PLATE XIV.

Elephas primigenius.

Fig. 1. Crown view of a right upper last true molar, No. 37,248, British Museum, from Millbank, Thames Valley, Middlesex. (Natural size.)

Fig. 2. Crown view of a right upper last true molar, No. 36,426, British Museum, from Lexden, near Colchester, Essex. (Natural size.)

Fig. 3. Crown view of a portion of a right lower last true molar, No. 40,699, British Museum, "dredged off Cromer Forest Bed," Norfolk coast. (Natural size.)

Fig 1.

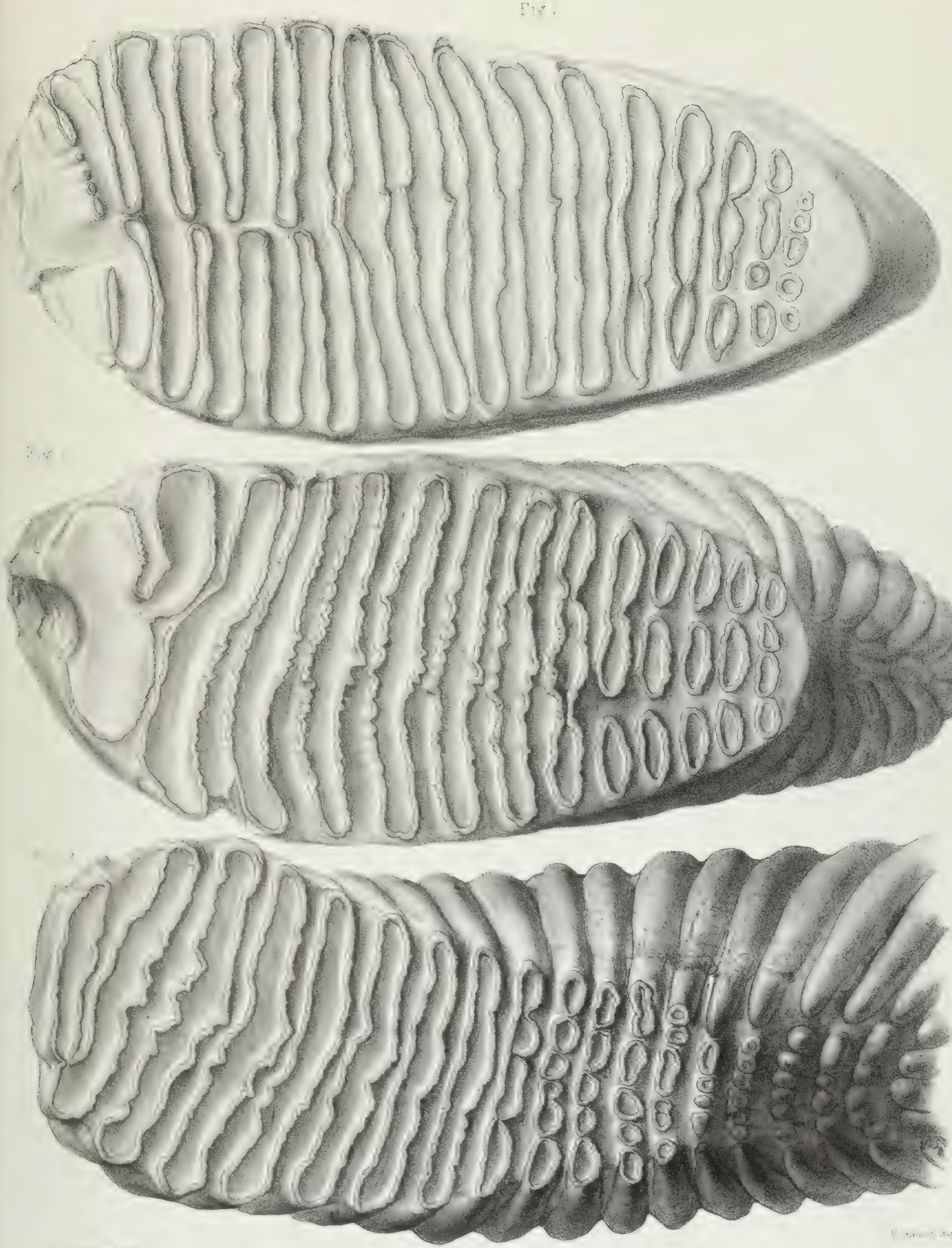


PLATE XV.

Elephas primigenius, E. Asiaticus, and E. Africanus.

Figs. 1, 1 *a*, and 1 *b*. External, anterior, and articular views of a left scapula, No. 119 c, Brady Collection, British Museum, from Ilford, Essex. (One fifth natural size.)

Figs 2 and 2 *a*. External and articular views of a right scapula of *E. Asiaticus*, No. 27,449 Museum Royal College of Surgeons of England. (Much reduced.)

Figs 3 and 3 *a*. External and articular views of a right scapula of *E. Africanus*, No. 708^{k}, British Museum. (Much reduced.)

Fig. 1.

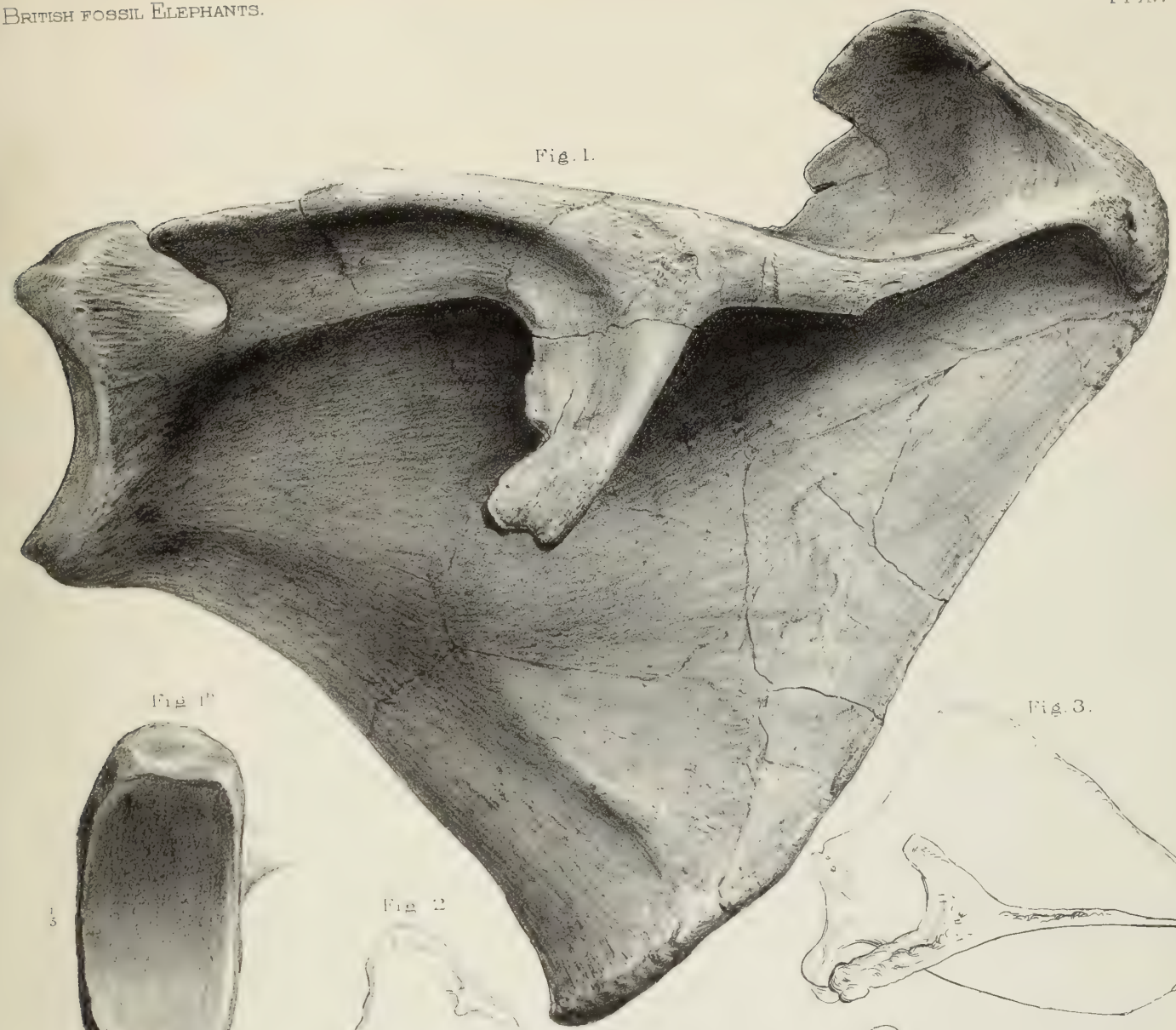


Fig. 1ª

Fig. 3.

Fig. 2

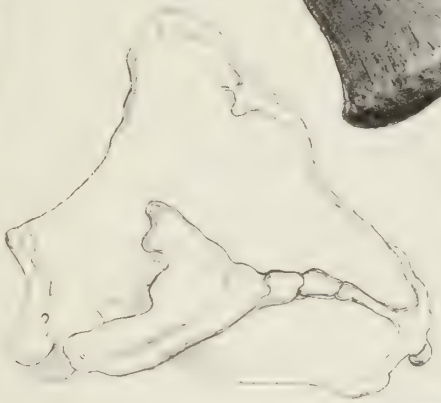


Fig. 2ª

Fig. 3ª

Fig. 1ª

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